1988 NASA AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION,
AVIATION AND MATERIALS

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

FIRST SESSION

MARCH 10, 11, 1987

[No. 20]

VOLUME I

Printed for the use of the
Committee on Science, Space, and Technology

U.S. GOVERNMENT PRINTING OFFICE
75-654 WASHINGTON : 1987

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

H 701-66

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

ROBERT A. ROE, New Jersey, *Chairman*

GEORGE E. BROWN, Jr., California
JAMES H. SCHEUER, New York
MARILYN LLOYD, Tennessee
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
HAROLD L. VOLKMER, Missouri
BILL NELSON, Florida
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
NORMAN Y. MINETA, California
BUDDY MacKAY, Florida
TIM VALENTINE, North Carolina
ROBERT G. TORRICELLI, New Jersey
RICK BOUCHER, Virginia
TERRY BRUCE, Illinois
RICHARD H. STALLINGS, Idaho
BART GORDON, Tennessee**
JAMES A. TRAFICANT, Jr., Ohio
JIM CHAPMAN, Texas
LEE H. HAMILTON, Indiana
HENRY J. NOWAK, New York
CARL C. PERKINS, Kentucky
TOM McMILLEN, Maryland
DAVID E. PRICE, North Carolina
DAVID R. NAGLE, Iowa
JIMMY HAYES, Louisiana
DAVID E. SKAGGS, Colorado***

MANUEL LUJAN, Jr., New Mexico*
ROBERT S. WALKER, Pennsylvania
F. JAMES SENSENBRENNER, Jr., Wisconsin
CLAUDINE SCHNEIDER, Rhode Island
SHERWOOD L. BOEHLERT, New York
TOM LEWIS, Florida
DON RITTER, Pennsylvania
SID MORRISON, Washington
RON PACKARD, California
ROBERT C. SMITH, New Hampshire
PAUL B. HENRY, Michigan
HARRIS W. FAWELL, Illinois
D. FRENCH SLAUGHTER, Jr., Virginia
LAMAR SMITH, Texas
ERNEST L. KONNYU, California
JACK BUECHNER, Missouri
JOEL HEFLEY, Colorado
CONSTANCE A. MORELLA, Maryland

Harold P. Hanson, *Executive Director*
Robert C. Ketcham, *General Counsel*
Regina A. Snyder, *Chief Clerk*
R. Thomas Weimer, *Republican Staff Director*

Subcommittee on Transportation, Aviation and Materials

DAVE McCURDY, Oklahoma, *Chairman*

DAN GLICKMAN, Kansas
BILL NELSON, Florida
TOM McMILLEN, Maryland
JIMMY HAYES, Louisiana

TOM LEWIS, Florida
ROBERT S. WALKER, Pennsylvania
F. JAMES SENSENBRENNER, Jr., Wisconsin

---

*Ranking Republican Member.
**Resigned February 19, 1987 (H. Res. 89).
***Elected March 30, 1987 (H. Res. 133).

CONTENTS

WITNESSES

March 10, 1987:

Page

- Dr. Raymond S. Colladay, Associate Administrator, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration, accompanied by Louis J. Williams, Assistant Director for Aeronautics, General Aviation and Transport Aircraft 2

March 11, 1987:

- H. Harvey Album, chairman, Congressional Aeronautical Advisory Committee [CAAC] and Dr. Barnes McCormick, CAAC cochairman and professor, department of aerospace engineering, the Pennsylvania State University 80
- Dr. John L. McLucas, chairman of the board, Questech, Inc., on behalf of the Aeronautics and Space Engineering Board, Commission on Engineering and Technical Systems, National Research Council; accompanied by Dr. James Kramer, chairman, and Dr. Robert Korkegi, Director; and Dr. Norris J. Krone, chairman, Advisory Committee on National Aeronautics, American Institute of Aeronautics and Astronautics and director, University Research Foundation, Greenbelt, MD 99
- Harold Andrews, chairman, Congressional Aeronautical Advisory Subcommittee on NASA's Aeronautical Advisory Committee and Advice and Assistance to Industry 134

APPENDIX

Report to Congress of the Congressional Aeronautical Advisory Committee 139

Summary report to Congress by a designated subcommittee of the Congressional Aeronautical Advisory Committee 203

Statement of the Air Transport Association 210

1988 NASA AUTHORIZATION

TUESDAY, MARCH 10, 1987

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Transportation,
Aviation and Materials,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:05 p.m., in Room 2325, Rayburn House Office Building, Hon. Dave McCurdy (chairman of the subcommittee) presiding.

Mr. McCurdy. The Subcommittee will come to order.

Dr. Colladay, there is a possibility if we have all the members of the Subcommittee up here at the same time, we may interrupt you, if we may, for just a minute to have a picture. If they don't show up, we will just continue as is.

Mr. Sensenbrenner. The gentleman from Wisconsin is planning on leaving in about 10 minutes.

Mr. McCurdy. We are going to move directly into his testimony and if the others show up, we will take a picture. If not, if they will make it, we will try again.

I appreciate the gentleman from Wisconsin and the gentleman from Maryland being here, and we will see how the rest—in what order they appear.

Today's hearing concerns the first "A" in NASA, a very important part of the Agency, that is sometimes overlooked by those who think of NASA as the "space agency."

NASA's aeronautics program has a long and impressive history, dating from 1915. It is also unique among Government agencies in terms of its track record of many successful innovations which have found their way into practical application in both military and civil aircraft.

Over the years, NASA's work has played a key role in keeping America out front in aviation, something that was vitally important in war time and which continues to bear fruit every day as our manufacturers compete in the world market.

Today and tomorrow we will examine NASA's budget request for aeronautics for Fiscal Year 1988. We particularly want to know if the proposed program and budget are adequate to meet the growing foreign challenge to our competitiveness in aviation products.

I note that the key line item for aeronautical research and technology is down slightly from last year, $376 million versus $375 million for this year, and that the number of people working in aeronautics is also reduced from 3,536 to 3,516. Perhaps even more disturbing is the fact that after accounting for inflation, NASA's budget is less than it was in 1981. I have to question whether this is the way to maintain our preeminence in aviation.

To help us look at this question, we have invited witnesses from the Agency who will appear today, and from several outside advisory groups, who will appear tomorrow. Also tomorrow in a separate joint hearing with the Armed Services Research and Development Subcommittee, we will hear testimony on the National Aero-Space Plane Program.

I understand our colleague, Mr. Lewis, is testifying before one of the other Subcommittees and will be here shortly. If there are no other statements, we will proceed with Dr. Colladay. His full statement will be entered into the record. I understand he will summarize that for us and then go to questions and answers.

Dr. Colladay, welcome. We are pleased to have you again today. I understand you had a successful ground breaking or dedication ceremony at Ames, and I understand there was a large crowd and very successful. I'm sorry I couldn't make it. Mr. Lewis was there. We are glad it was a success.

STATEMENT OF DR. RAYMOND S. COLLADAY, ASSOCIATE ADMINISTRATOR, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY LOUIS J. WILLIAMS, ASSISTANT DIRECTOR FOR AERONAUTICS, GENERAL AVIATION AND TRANSPORT AIRCRAFT

Dr. COLLADAY. Thank you, Mr. Chairman. It was a success, and if I'm a little sleepy today, it is because I came back late last night on the Red Eye. But, it was such an event for aeronautics that we were all proud to be a part of it.

I am pleased to be here to present NASA's FY 1988 Aeronautics budget request. With me, I have my management team. I won't take the time to introduce all of them but I would like to indicate that my Deputy, Dr. Rosen, is here behind me, as is Cecil Rosen, the Director for Aeronautics. The two Rosen's aren't related and that causes some confusion, nevertheless, they are part of the team. My Assistant Directors are with me as well.

I'd like to lead into the 1988 budget request looking at what we have been able to accomplish in this past year. It's impossible to capture the full impact of a program as broad and as comprehensive as the NASA aeronautics program is but I'm going to try in the next few minutes to leave you with an impression of just what we have been able to accomplish this past year. With all of the problems that NASA has experienced over this past year, aeronautics has stood out as one of the bright spots in the Agency.

First of all, as we have just discussed, we have begun full operations on the world's most advanced computer complex dedicated to aeronautics (Figure 1). The dedication ceremony was held just yesterday, and we already have approximately 300 users nationwide that are part of the network of designers and researchers using this facility.

We didn't wait for that dedication ceremony. We were already using it and we completed the first numerical flow simulations over an F-16 aircraft for improved performance (Figure 2).

We are also using it for internal flow in engines and turbine machinery that shows the thermal mapping in blade rows indicated on Figure 3. We have also pressed it into service for supporting the Langley effort in the solid rocket motor design (Figure 5). When you have a capability like the NAS, you use it. In fact, it's virtually saturated already with the National Aero-space Plane calculations which are shown on Figure 4 of flow over a generic hypersonic vehicle at various axial locations down the vehicle from the leading edge to the trailing edge.

The same analysis that was used in that flow field has also helped us in designing a variable flow inlet on the scramjet engine (Figure 19) for the National Aero-space Plane. In record time, we designed, fabricated and got this configuration under test to support the industry and our part of that program.

The cryogenic wind tunnel at Langley that we call the National Transonic Facility has been in full operation this past year. We showed testing in a joint program with the Navy, the A-6 aircraft (Figure 6), to study extending the stall spin characteristics of that vehicle.

We also have done extensive testing in understanding characteristics of high angle-of-attack, vortex shedding and propulsive controls in vehicles that can operate stably near 90 degrees angle of attack as shown in Figure 14. We have tested various configurations in the 30 x 60 wind tunnel at Langley for stable operation at about 80 degrees (Figure 15).

We used the same tunnel for a number of test configurations. This is a joint program with Cessna where we have evaluated an advanced wing for natural laminar flow control on an actual aircraft installed in the 30 x 60 wind tunnel (Figure 9).

We also have been looking at the natural laminar flow as a function of wing sweep in tests done just this last year in the F-14 (Figure 10). We have completed flight tests on the JetStar of two active laminar flow configurations with Boeing, Lockheed and McDonnell Douglas under normal airline-type operation (Figure 11).

We have completed the first time-dependent flow characteristics in the rotor plane of a helicopter (Figure 8) to build the database to verify the analytical codes that are coming out of our CFD Program and back to flight tests. We have flown a riblet tape on the side of a LearJet fuselage (Figure 12) to reduce turbulent drag. This is the same material that was licensed to 3M and put on Stars and Stripes for the America's Cup challenger.

We are reaching the peak of our activity in the high speed turboprop program where we have laid the technology base that has enabled GE and Boeing to complete successfully the flight tests of the unducted fan (Figure 16) and our own flight tests of the high-speed single-rotation propeller test-bed will occur in April or May of this year.

We have completed evaluation of the collision avoidance system, TCAS II, (Figure 21) for the FAA this past year. Elsewhere in our safety program, we have continued with full operation of our advanced cockpit simulator (Figure 22) and various configurations affecting automation and safety in future aircraft.

Heavy rain effects are a problem that we have begun to explore (Figure 23) and by evaluating the effects of lift degradation as a result of heavy rain effects.

We flight tested this past year a variable camber wing configuration on an F-111 vehicle (Figure 13) and we have completed the flight test initial envelope exploration (Figure 24) of the X-29 forward swept wing at Dryden. We had the rollout this past year of the new X-wing (Figure 25) installed on our NASA Rotor Systems Research Aircraft that will be used to evaluate transition from vertical to horizontal flight. The tests begin in May of this year.

That's a very brief snapshot of some of the accomplishments in the program this past year. It's a dynamic and productive program, well connected with the industry in doing the right things.

I can assure you, Mr. Chairman, without reservation, that the American people are getting their money's worth out of this program; dollar for dollar, it's one of the best, highest leverage investments in the Federal Government.

I'm fully aware of the external advice that the program is underfunded and should do more, and I wish we could do more. Growing foreign competition demands that we stay ahead in technology development. Aerospace, particularly the aeronautics sector, is one of the few bright spots in the U.S. balance of trade picture.

This U.S. leadership in aeronautics has not happened by accident. It is the result of a highly successful industry, government, and university partnership that has evolved since the founding of NASA over 70 years ago.

But the picture is not as rosy as the trade statistics would indicate. In fact, other nations now dominate the world general aviation market, account for nearly half of the world's sales in rotorcraft, and Airbus industries is achieving a growing market penetration in the commercial transport market with the A-320 and projections of the A-340.

Technology can make a difference. Historically, when we have been first in applying advanced technology to innovative configurations, we have led the world. We have laid out this past year a coordinated strategy for dealing with aeronautical R&D on a national level.

The Office of Science and Technology Policy (OSTP) has issued two reports—the national goals report and its sequel implementation plan—in an effort to coordinate the Government, industry and universities in achieving leadership in aeronautics work on all three of the major goals of that report in subsonic, supersonic and transatmospheric flight regimes is in progress.

The sequel report, Agenda for Achievement, and usually referred to as the Bird Book II, has been released by the OSTP as of several weeks ago. It spells out the action to be taken in eight discrete areas for U.S. leadership in aviation.

NASA has a prominent role in most of these eight recommended actions. Our leadership is particularly stressed in developing the fundamental knowledge base in emerging technology areas. As with the original national goals report, this latest report will influence aeronautics planning in our future budget requests.

The Aeronautics budget request for FY 1988 is $375 million and allows us to move forward in several new areas and continue the very significant momentum in important areas against these goals.

I'd like to mention two areas in highlighting their importance in this year's budget request. One is wind tunnel efficiency enhancement, which provides a down payment to improve productivity of our most critical high demand wind tunnels. Too often, there's a tendency to put new capability ahead of modernizing existing facilities. I will not do that.

These wind tunnels are essential to preserving U.S. leadership in aeronautics and I'm very concerned about the combination of age and increased demand that we are looking at right now. That is why I have initiated a comprehensive wind tunnel study to assess their integrity, capability and capacity and to develop an implementation plan and various options. It should be completed later this year.

The second area is high-temperature engine materials, a new line item in this budget. It represents a consolidation and expansion of ongoing materials research in ceramics, carbon/carbon composites and metal matrix composites. They promise improvements that are crucial to efficient supersonic cruise and short takeoff and landing vehicles.

Let's look at the three R&D goals now against the program that is in place in the request for FY 1988.

As for the subsonic goal, technology that we have invested in over the past 10 years, more than $1 billion as part of the Aircraft Energy Efficiency program, is maturing to the point where U.S. industry is applying the products to its 1990 product developments. But, there is more to do.

We are currently focusing on replenishing the technology base with major emphasis on aircraft automation; aviation safety where we are studying windshear modeling; airborne detection of windshear and heavy rain effects; and advanced composite structural design concepts to improve the fundamental knowledge base to fully exploit these light-weight materials.

Laminar flow concepts need to be explored, and we intend to do that with high Reynolds number, large chord flight tests, turbulent drag reduction and quiet, smooth rotorcraft as a part of the subsonic area of the R&D goals.

The supersonic goal remains one of the great opportunities that is yet to be exploited. During this past year, we embarked on a major high-speed transport study with the industry to examine the market opportunities, to determine the necessary economic characteristics and environmental implications of such aircraft and to identify the most promising advanced technology that needs to be worked and put in place for such vehicles to show the promise and exploit those vehicles for the future.

Also in the supersonic area, we are continuing to explore technology for highly maneuverable vehicles and short takeoff and landing concepts.

In the transatmospheric regime, we are right on track. NASA's aeronautics research related to hypersonic flight has been successfully transitioned to the National Aero-space Plane Program which you will review in detail tomorrow. This bold new initiative is sustaining U.S. leadership and stimulating a major expansion of research in all of the technologies key to transatmospheric and hypersonic flight.

In summary, Mr. Chairman, technology has been the cornerstone of our leadership in aeronautics, as you observed. It still remains the decisive factor. NASA plays a central role in developing and transferring this technology, a responsibility which we take very seriously. Within the overall constraints on the Federal budget, NASA has an outstanding, highly productive program. I think we are doing the right things and we are doing things right.

The country's investment in NASA's aeronautics program has the highest leverage, as I pointed out, and payoff, to our long-term economic security and defense of any Federal R&D investment. I wish we could do more. The national R&D goals for aeronautics in the recently issued Agenda for Achievement outline enormous opportunities for aviation and will shape our future program requests as we look at what the Government, industry and universities must do collectively.

In closing, let me say that I appreciate the support that this Subcommittee has given to NASA's aeronautics program over the years. I think that support is paying off now.

Thank you. That concludes my remarks. I'd be happy to answer any questions you have at this point in time.

Mr. McCurdy. Thank you, Dr. Colladay, for a very good statement and as I said earlier, your full statement is admitted into the record.

We have a wide range of areas we need to explore today. Before I get into the specifics, I was particularly taken by your last statement, your concluding statement in your prepared text regarding the U.S. aerospace industry and the trade deficit and the fact that in 1986, we had $11 billion surplus in that particular export sector, whereas we had what, $160 billion deficit overall.

You mentioned the leverage that NASA aeronautics dollars have vis-a-vis other research and development programs in the Federal Government.

I take that to be true and I think this Subcommittee has been supportive of that effort. NASA has the Full Committee. If this Administration is serious about addressing the trade deficit, about addressing the technology of the future, then why is it that this budget in real terms is less than what NASA had in 1981, when the problems in 1981—we didn't have the massive deficit problems. We didn't have the trade problem. Yet, the few bright lights that we see to help lead us out is actually curtailed.

Is it just strictly OMB fights or what is the problem?

Dr. Colladay. Well, we are rebuilding from reductions we took after 1981. We went through some soul searching within the Administration about whether aeronautics had reached a point of diminishing returns and should no longer be supported by Federal investments in R&D. We changed that impression. There's no question that we haven't hardly begun to see the payoff, the promise of advanced aeronautical vehicles. As a result of various policy studies that the Administration did, we have gradually been rebuilding and changing the direction of the NASA aeronautics program to strengthen it.

It's true in absolute dollars that the FY 1988 request is $1 million below the FY 1987 level. But, taken over a two-year period, which I tend to look at the trends for the longer term growth pattern, and including the National Aero-space Plane which is a very important aeronautical vehicle, the growth in the NASA aeronautics program is 30 percent over those two years.

Mr. McCURDY. Primarily because of the Aero-space Plane?

Dr. COLLADAY. Primarily because of the Aero-space Plane. Another way to look at the 1988 budget, Mr. Chairman, is that the run out of the 1987 level to 1988 was $10 million less than we are showing this year because various programs were coming to successful completion. So, there is a growth from last year's run out to 1988; but the level is essentially, with that taken into account, maintaining inflation.

Mr. McCURDY. Was the aeronautics budget line reduced to cover the increases for the Aero-space Plane?

Dr. COLLADAY. No. It wasn't reduced to support the Aero-space Plane. I look at the Aero-space Plane program as a new initiative on top of the aeronautics program. That's why I elected to show it as a separate line item so that it would not dip into the aeronautics program and eat the resources that are vital to the long-term aeronautics program.

Mr. McCURDY. Well, the number of people in aeronautics was reduced, as I indicated earlier, whereas the Agency overall received an increase of some 625 positions. How do you explain that?

Dr. COLLADAY. The manpower level in aeronautics was reduced slightly, by 24, I believe this is essentially a constant level. The 625 increase that the Agency received has been targeted at the areas specifically recommended by the Rogers Commission for increases. The aeronautics program was not one of those, so we are essentially level in manpower. Again, that's taking National Aero-space Plane and aeronautics together.

Mr. McCURDY. The 12 foot pressure tunnel at Ames has been used extensively by industry. Would you describe its present condition and your plans to restore it to full capacity?

Dr. COLLADAY. The 12-foot tunnel is one of the key workhorse facilities that is in NASA's inventory. In fact, it has been used for virtually every airplane development in the last 40 years.

Mr. McCURDY. It's 40 years old. It's older than this Chairman. [Laughter.]

Dr. COLLADAY. Wind tunnels do wear out. This one reached its fatigue life.

Mr. McCURDY. Chairmen wear out also but it is older than this Subcommittee, as a matter of fact, both members of this Subcommittee that are present. What are we going to do with it?

Dr. COLLADAY. I've initiated an indepth assessment of the cost to recertify the tunnel to its original operating condition of six atmospheres. It looks like we are going to have to replace the shell of the tunnel and there are also some productivity improvements that you would want to make at the time you replace the shell. I'm looking at the full cost of those modifications and extending that study which was started 9 or 10 months ago, to all of our facilities for aeronautics. That tunnel needs to be repaired and brought back on line. I intend to do that. But, as yet, I don't know the full impact of the cost of doing it.

The initial estimates are on the order of $50 million, so you can see why we need to take very deliberate and careful action on it with a budget of that magnitude.

Mr. **McCurdy**. Would you restate that? I got beeped right in the middle of your dollar figure.

Dr. **Colladay**. The initial estimates are $50 million for repairing and restoring the tunnel.

Mr. **McCurdy**. Do you expect—will your study be completed in time to request a supplemental or will it be deferring to the 1989 budget? Where do you see the request?

Dr. **Colladay**. It will be done in time to request a supplemental if we elect to go that way. That is why I started this study when I did. The question of whether a supplemental is appropriate depends on how quickly we can get the work crews together and when the budget needs to be in place. I'm looking at that as an option.

Mr. **McCurdy**. We have a couple of more minutes before we have a series of votes. Does the gentleman from Maryland have a line of questioning he wants to pursue before we go vote?

Mr. **McMillen**. I wanted to ask some questions about composite technology, Mr. Chairman, but I'm not sure—maybe we should do it when we get back.

Mr. **McCurdy**. Why don't we defer then? It looks like it is a series of suspension votes, probably five minutes each, so we are talking unfortunately probably about another 20 minutes, minimum, depending on how many votes there are. We shouldn't be much longer than that. We will come directly back so if you need to take a quick coffee break, we will do it at this point.

Dr. **Colladay**. OK; thank you.

[Recess.]

Mr. **McCurdy**. Well, that takes care of that. Sorry for the interruption, but it comes with the territory around here.

You showed one of the slides, the prop fan technology. I was recently at Savannah and looked at the aircraft there that's being fitted with the single-blade jet.

Now that industry apparently is picking up on that, GE with theirs, and they've had a lot of publicity on it recently, where do you see this technology, and what is going to be NASA's continuing role here?

Is this something that is about to be handed over, or is there a lot left to be done?

Dr. **Colladay**. The initial handoff has occurred, I think, in splendid fashion, particularly with the unducted fan with General Electric and Boeing. But that's only one particular configuration. Much work still needs to be done in establishing a good data base that can answer questions of scaling and aeroelasticity effects of different blade configurations at different Mach numbers and aeroacoustic characteristics of the blades and installation aerodynamics.

There are a number of things that need to be done in what I'd call the R&T base that you've got to put in place to support various product concepts that will come along downstream, and NASA will do that in its base program. We laid out a program that would look at a number of counter-rotation and single-rotation concepts, and we had a wind tunnel program which led to flight tests to determine the scaling effects.

We realized that after the flight program we really needed to be involved over the long haul, the same way we do in turbofan engine technology 20 years after, in high bypass ratio turbofans that were put into service.

So I see a level of effort that must continue and will continue in the NASA aeronautics program, supporting the industry after the flight test.

Mr. McCURDY. Do you expect—I didn't see the results of the GE test, but are the—with their props in the rear, are there fewer—or do you expect fewer acoustic problems and vibration problems than you expect on the other?

Dr. COLLADAY. Well, the acoustic problems in the cabin per se will be somewhat less with a rear-mounted, pusher propeller because the plane of the propeller is behind the bulkhead.

Structural-borne noise, which is also a problem that needs to be addressed, will be similar for a wing-mounted or an aft-mounted, more centerline configuration.

The purpose for our flight test on the Gulfstream is to get a clean inlet and tie the flight data to the wind tunnel data to answer the scaling effects question. Once you have the correlation between flight and wind tunnel and you have the clean inlet that a wing-mounted tractor drive provides, then the design systems can, with more confidence, look at the other configurations.

So the cabin environment specifically will likely be less severe for an aft-mounted propeller than a wing-mounted.

Mr. McCURDY. Have the flight tests borne out the expectations as far as increased efficiency and what other characteristics you were seeking with this technology?

Dr. COLLADAY. There are still improvements that need to be made in both propulsive efficiency and reduced noise that we're sure will come; but, so far, the performance has met all of the expectations.

Mr. McCURDY. About what has been our investment so far, the Government's investment?

Dr. COLLADAY. I can provide that in the exact amount for the record, but it's on the order of $75 million if you go back to the mid-1970s when we started the basic research program.

[The requested material follows:]

The Government's investment in NASA's Advanced Turboprop Systems program from fiscal year 1978 though fiscal year 1985 was a total of $75.3 million. The funding for fiscal year 1986 through fiscal year 1988 is as follows:

[Dollars in millions]

Fiscal year:	
1986	40.0
1987	26.0
1988	18.0

Mr. McCURDY. About what do you consider—what do you project industry's share of the cost to be or have been?

Dr. COLLADAY. I'd say all told, the industry investment has probably been close to matching the Government investment. When they proceed with the technology that's been developed and develop products, then, of course, their investment will be an order of magnitude more than ours in the technology base.

Mr. McCurdy. The staff tells me it's $92 million, so that's in the range. And you think that industry has pretty well matched that? It's a fairly good cost-sharing arrangement?

Dr. Colladay. Yes, it is.

Mr. McCurdy. It sounds like a pretty good investment.

What progress is being made in developing an airborne windshear detection system?

Dr. Colladay. We have a joint program with the FAA and an MOU to develop instrumentation for airborne detection. We're just in the second year of that effort and, as yet, have not flight-demonstrated the laser Doppler system that we're developing. But, the prospects look good for a successful development.

Mr. McCurdy. The XRAD system, of course, is in a different subcommittee, but I'm on that subcommittee also, and I know we have portions of it in DOD.

What kind of involvement or relationship do you have in the testing and development of that system?

Dr. Colladay. Excuse me. Which system did you say?

Mr. McCurdy. XRAD, on the radar system, which is, of course, weather radar which does the groundbased windshear question, and I was curious if there is any interface.

Obviously, there's not, if you're not familiar with the system.

Dr. Colladay. I'm not familiar with what we are currently doing.

Mr. McCurdy. Well, it's a new one.

Dr. Colladay. Apparently.

Mr. Williams. Well, we are involved with the FAA, and that part of the program, of course, complements the airborne Doppler system.

Mr. McCurdy. Well, I was just curious, if we are going to go into this area, there has to be obviously some coordination and interface, and maybe I'm just alerting you to the issue.

Dr. Colladay. I'll look into it.

Mr. McCurdy. And be aware of it in the future, and I would certainly recommend that you get more involved in their—at least following what they're doing.

Would you identify yourself for the record, by the way.

Mr. Williams. My name is Lou Williams.

Mr. McCurdy. We understand that the Navy has pulled out of the oblique wing program. Why and what effect do you think this is going to have?

Dr. Colladay. We haven't gotten official notification that they have backed out, but that's the unofficial word from them. We're looking at different options of how to proceed with the program. They range from another service of DARPA picking up the DOD share, all the way on the other hand to cancelling the program. I, as yet, haven't made a decision on what we are going to do, but we will not proceed with that program unless the DOD matching share is in place.

Mr. McCurdy. I'm going to recognize Mr. McMillen, who has a series of questions, and while he's doing that, I've got to meet with someone, and so he has the chair, and I will be back.

Dr. Colladay. Okay.

Mr. McMillen [presiding]. Thank you, Mr. Chairman.

Dr. Colladay, I'd like to ask you some questions about composite technology, an area that I've been interested in, and maybe you could give me some perspective on it from an international standpoint.

One of the things that I'd like to look at in terms of the composite development is really to compare that to the Japanese and other nations around the world. It's said that Japan now has 70 percent of the world market for ceramics and electronic applications, and most, if not all, the fibers from graphics originate from abroad.

What does that mean in terms of our future in the composite technology area? We are so dependent upon the Japanese and other nations for these materials.

Dr. Colladay. As far as aircraft structural composites are concerned, we're maintaining the lead, I think, internationally in application of thermosets and, in the future, thermoplastics for secondary structures.

NASA has invested heavily over the years in aircraft composites. I'm sorry to say that we haven't gotten to the point where the technology lends itself to be applied to main structural composites like the wing box. But we are making progress. In that area, I think the U.S. does lead.

In ceramics, there is a real concern that the Japanese, with their aggressive research and development in ceramics, could outpace the U.S. And for that reason, we've stepped up our advanced materials program for high-temperature composites for engines in ceramics and high-temperature airframe structures.

Mr. McMillen. Can you give me an idea of the—when you say "stepped up," what that means in dollars and cents?

Dr. Colladay. We've had, as a joint program with the Department of Energy, a ceramics program. We're increasing that in FY 1988 to a level of $10 million which represents about a doubling of our current effort.

Mr. McMillen. It's estimated that worldwide sales of advanced composites have been projected to grow by 15 percent annually for the remainder of the century, increasing from $1.4 billion to nearly $12 billion by the year 2000.

Studies have shown that composites could account for more than 65 percent of the structural weight of commercial aircraft, such as Boeing 757.

Does NASA plan to share with civilian manufacturers its composite knowledge?

Dr. Colladay. We are, Mr. McMillen, doing a lot of transfer of technology out of our laboratories into industry. In fact, we are working jointly with industry in developing advanced composite resins and fibers and working with the DOD jointly in manufacturing technology for composites.

I was concerned about the pace of the NASA technology program and, indeed, the pace of the national effort in applying advanced composites to aircraft and asked the National Research Council last year to conduct a study to make recommendations to me on what we should do to put in place the technology for transitioning into structural composites.

Their recommendations are reflected in part by the program advances that we plan to make in 1988.

Mr. McMillen. What are some others—just for my edification, what are some other civilian uses, that you can foresee for composites, based on the results of your work?

Dr. Colladay. Well, of course, automobiles would be an area where, if you could solve the manufacturing problems, the demand and the amount of materials processing that would result from applying them to automobiles would move that industry along with a tremendous infusion of capability that would be felt across the entire country in all manufacturing sectors.

Airplanes, we've seen for a long time, show promise of composite applications, and I'm sure there are many others.

Mr. McMillen. Well, clearly this is a promising technology. In the agenda for achievement, they talked about really focusing your efforts on the highest potential payoffs.

In Fiscal Year 1986, NASA eliminated a $19 million program in advanced polymer composite technology. What is the size of your polymer composite program in Fiscal 1987, and what are you proposing in Fiscal 1988?

Dr. Colladay. It's about $3 million in FY 1987, $4.5 million planned in FY 1988. That's a different program than the one that was terminated two years ago. It is increasing emphasis on thermoplastics, as opposed to thermoset resins, and establishing a leapfrog of advanced materials over what we were planning to do in that old program.

Mr. McMillen. If you might add, what have you asked for in Fiscal 1987 and 1988 in your budget preparations for those two programs?

Dr. Colladay. Those two figures are what we asked for in 1987 and 1988.

Mr. McMillen. Let me rephrase the question. I should say, if you could, I guess, in an ideal world, what would you ask for? Are you satisfied with those numbers?

Dr. Colladay. Not at the level that it needs to be funded beyond 1988. We've built the program up from zero, when it was terminated, to $3 million and then $4.5 million. I think to do the right program that we're embarked on now, we need on the order of $7 to $8 million.

Mr. McMillen. In Fiscal?

Dr. Colladay. In Fiscal 1989.

Mr. McMillen. Let me ask a couple of other questions in this regard.

Given the success of the Voyager flight, among others, with advanced composites—I guess this is a continuation of the question I just asked—do you feel that this amount is sufficient, the dollars that you're allocating?

Dr. Colladay. It's a rather spartan program, but we are building it up. I think it's sufficient right now, but it's not sufficient, as I indicated, for the level it needs to reach.

If you get into the large sections of a wing box or major structure of an aircraft and have to demonstrate the load-bearing structure capability of composites, then we would need to get into a program that was an order of magnitude higher than that.

But right now, we're trying to do the basic materials and design research leading to a new generation of composite materials, and for that, it's sufficient.

Mr. McMillen. How do your efforts compare with the DOD?

Dr. Colladay. DOD's effort is primarily focused on manufacturing technology, and NASA's is coordinated with that effort. We're focusing on materials and design. Together, they—the two programs complement each other.

Mr. McMillen. Do you know the dollar amount, the comparable dollar amounts?

Dr. Colladay. I don't, Mr. McMillen. I can find that out for the record.

[Information to be furnished follows:]

NASA's organic composites program focuses on expanding the materials and structures research and technology base, including development of new materials, design concepts, and subcomponent fabrication and test. These programs are funded at the level of $3 million in fiscal year 1987 and planned for $4.5 million in fiscal year 1988.

DOD programs focus on research and technology base, as well as support of composites applications, including damage-tolerant design and repair technology ($18.6 million in fiscal year 1987) and manufacturing technology to demonstrate cost effective fabrication methods for large-scale or production components ($20.8 million in fiscal year 1987). These efforts total $39.4 million in fiscal year 1987 and are planned for approximately the same level in fiscal year 1988.

Together, the NASA and DOD programs are complementary. NASA's base research and technology DOD application and manufacturing technology programs, as well as technology for application of composites to commercial aircraft.

Mr. McMillen. Just in conclusion, you know, it seems to me that if projected sales of advanced composites are projected to be on the order of $12 billion in the year 2000, and we're spending, you know, $3 million in Fiscal '87 and 4.5 in Fiscal '88, I'm not sure there really is not a disconnect between what really makes sense for our future and really leveraging the kind of technology that you talked about in your opening statement.

And I just kind of wanted to make that apparent for the record.

Mr. McCurdy [presiding]. I think the gentleman raises an excellent point, and Dr. Colladay wasn't there. He's probably happy that he wasn't, if you'd seen the tenor of the meeting.

Yesterday, we had—was it yesterday—sometime, maybe it was Friday, I guess—we had an R&D Subcommittee hearing in Armed Services, and we had Dr. Graham, the Science Advisor, and Dr. Gerber, who does the S&T for the Department of Defense, and I was raising very similar questions.

I wasn't using composites; I used ceramic technology, ceramic turbine development, ceramic parts of engines and development in the general area.

And I was asking about the coordination. Where was the Federal Government in this important technology area? And they indicated that when we had the hearing on the advanced gas turbine engine, the only part, ceramic part, that worked was the Japanese part, and it didn't last forever, but it worked better than anything else we had domestically.

So I was trying to follow up on that. And so we look at the NASA budget, and for ceramic turbine technology, the line item has dropped from like $5 million last year to zero this year.

So I asked the Department of Defense where theirs was. $125 million.

Now how in the world can you tell me that that is coordination? I mean, that is dominance. That is absurd, because all the R&D in the world cannot be done in the Department of Defense, and all of the transferable technology can't be done in the Department of Defense.

And for the life of me, I don't understand how that can be canceled out here, if it is a high priority national issue. And it can apply to composites; it can apply anywhere.

And the mentality in DOD is, "We can solve the problems if you give us enough money."

Now NASA may have had that a few years ago, but obviously today, OMB or someone is dictating to you that you are no longer a key player in this area.

Do you disagree with me?

Dr. COLLADAY. The ceramics, yes, I disagree with you. I think we are a key player in this area. The ceramics program didn't go to zero in FY 1988. It was transitioned into the high-temperature materials program that I referred to in my statement as one of the new areas that has been augmented in FY 1988, in ceramics and high-temperature composite materials.

We tend to work with the DOD where we take the front end, the basic, fundamental materials research and they concentrate on the applications which are more costly component parts. The program is coordinated between the Materials Lab at Wright Field and the Lewis Research Center.

Mr. MCCURDY. Well, the entire high-temp engine materials technology is $10 million for 1988. Is that just ceramics?

Dr. COLLADAY. It's all engine composites. Ceramics is about a half of it.

Mr. MCCURDY. The engine blade coating and other technologies? What types of areas?

Dr. COLLADAY. It's metal matrix composites for exhaust nozzles, for example, and silicon carbide, silicon nitride turbine materials that we have been doing with the Department of Energy in a joint program over the last ten years.

Mr. MCCURDY. Where is DOD doing their research?

Dr. COLLADAY. At the Materials Lab at Wright Field.

Mr. MCCURDY. So you're saying you're working in the same shop or what?

Dr. COLLADAY. Our laboratory is Lewis Research Center, and they're working with Wright Field.

Mr. MCCURDY. Well, I understand that. I'm more concerned about coordination. I'm concerned about the direction. I'm concerned about the interface between the two agencies and the ability to—for instance, Dr. Graham made a statement that, you know, because of the budget, we have to do with what we can. We have to make it with what dollars we have, and we can't invest in new technologies that much. Industry is going to have to take a greater role.

And I asked him the question about, was he aware of the Mantech program.

Do you know about Mantech? Do you have a Mantech in NASA?

Dr. COLLADAY. Manufacturing technology is an area that historically NASA has not had much R&D in.

Mr. MCCURDY. Right. Well, DOD spends close to a billion dollars a year on it, and it's a billion dollars to develop new manufacturing techniques and R&D in manufacturing.

And basically the question I have is, how is it that DOD can spend nearly a billion dollars in supporting its industry, whereas other industries, whether it's automotive or general aviation or whomever, is left hanging?

And the argument is, of course, well, we're going to save money because they do such high-volume contracting work for the United States.

My point is that I think there's a disconnect here that, you know, it's kind of like what's good for DOD is good for America. Well, I think there are some other areas that we could use this in, and I'd like to see it explored.

And I don't know what direction you're getting. I don't know, Dr. Colladay—we don't know each other that well, and I don't know where you get, you know, the coordination and the direction.

Is someone giving you advice on how to coordinate this with DOD, or is it coming up from the grassroots? Where do you make these decisions?

Dr. COLLADAY. Well, we have an Aeronautics and Astronautics Coordinating Board (AACB) with the DOD, and of that Board, we have an Aeronautics Panel that my Director for Aeronautics co-chairs with one of Dr. Kerber's deputies. Our planning and coordination from Washington comes through that joint panel of the AACB. Then, the laboratories in the field work together in planning and conducting programs. At the grassroots, there is a lot of cooperation and collaboration in the research program.

So it occurs at both those levels. And, I have DOD members on my Advisory Committee that share with us what their plans are downstream of current budgets. We coordinate our planning through that mechanism with the DOD too.

Mr. MCCURDY. Is there any difference in the issue of proprietary rights and ownership of data between the research you conduct and what DOD does?

Dr. COLLADAY. All of the research that NASA conducts is published or released for early domestic dissemination to all of the U.S. industry.

Mr. MCCURDY. I understand that. That's my point. DOD does not.

So in the area of ceramic technology, composites—you know, I'm not talking about Stealth technology; I'm not talking about perishable technologies of the future—I'm talking about technology that could be easily translated and could be one of the most competitive issues for future U.S. industry. And yet we see that DOE found out that the only blade that worked or the turbine part that worked was the Japanese.

I hear the story a lot, being on the Armed Services Committee and on Intelligence, too, about how we coordinate because of, you know, horizontal communication, and yet we continue to see horror stories that it doesn't always work.

I want to know where—you obviously feel that that's sufficient?

Dr. COLLADAY. The coordination or our budget for ceramics?

Mr. MCCURDY. [Laughing.] Well, one leads to the other. I mean, if there was greater coordination, maybe NASA would have gotten a bigger share, or maybe you guys don't fight as well. I don't know. Is it just the deep-pockets mentality over there?

Maybe you want DOD to do it all. Maybe they can fund it, so you can go work on the Aero-Space Plane or something. I don't know. I need to find that out. I think this subcommittee would like to know how you arrive at those decisions and whether or not there should be greater direction from somewhere for this.

Dr. COLLADAY. Well, the decisions on the planning of the program come through what I think is adequate coordination as I indicated.

In the budget levels, they're decided as a result of the various channels that it goes through and the OMB examiners. We try to lay out a program that both maximizes the budget that we can apply for aeronautics and strongly advocate what needs to be done for our share of many of these coordinated programs. Then, we make sure that we do the right thing with the resources we have.

Mr. MCCURDY. What additional work did you request from OMB that was not granted or approved?

Dr. COLLADAY. The high angle of attack, what we call high-alpha, technology was requested and denied as a new start.

Mr. MCCURDY. How much was that?

Dr. COLLADAY. $10 million in 1988.

Mr. MCCURDY. Other areas?

Dr. COLLADAY. That's the only area.

Mr. MCCURDY. Did you offer anything up to be cancelled?

Dr. COLLADAY. No.

Mr. MCCURDY. Any savings in other areas?

Dr. COLLADAY. There were no other areas in aeronautics that were cut. We were just denied the new start initiative because it fell under the general banner of a new start. They were denied.

Mr. MCCURDY. DOD hasn't had that much trouble with their new starts.

Are there any areas that you think were in such an advanced state that perhaps we could save money by handing it off to industry? Are there areas of savings that you can recommend?

Dr. COLLADAY. That's a question we ask ourselves every year and throughout the year, Mr. Chairman. I think the program is so lean in areas across the board we're trying to cover that I couldn't identify a single area that I would conclude had reached the point of transition, where we could get out—the one exception being the uncertainty associated with the oblique wing. As I indicated, I would not continue that program.

Mr. MCCURDY. Because the Navy is not putting up their fair share?

Dr. COLLADAY. Yes.

Mr. MCCURDY. The X-29, you showed the one Vu-graph of it, and I'm very familiar with it from the DOD side of the house.

Where is that now? What's the status, and what do you foresee? I mean, what is your basic gut feeling there?

Dr. Colladay. Well, it completed the original flight expansion envelope with a limited control system. We're going to continue the flight testing with an advanced control system. We're looking, with the Air Force, at bringing the second vehicle along. The Air Force would do that to use it as a high angle-of-attack test-bed.

There has been no decision to do that at this point, and it will depend on the Air Force's willingness as a user service, to conduct a cooperative program with us. Otherwise, we will use the vehicle we already have to extend the flight envelope with the advanced control system, and the program would end in FY '88.

Mr. McCurdy. Is that Grumman?

Dr. Colladay. Yes.

Mr. McCurdy. Grumman is the contractor on that?

Dr. Colladay. Yes.

Mr. McCurdy. You say it's the Air Force's reluctance?

Dr. Colladay. I wouldn't say it's a reluctance yet. It's the handoff that's got to occur between DARPA and the Service, and that isn't always a smooth transition.

Mr. McCurdy. So if there's better coordination at the front end, they might have easier handoffs at the other.

I don't think DARPA gets its share either. I'm making my bias known here. Just because it's DOD, I'm not sure it's as sacrosanct as some people make it out to be.

At this point, I will recognize the gentleman from Pennsylvania, if he would care to inquire and come back to other questions.

Mr. Walker. Thank you, Mr. Chairman.

Is the kind of money we are spending on aerospace plans this year sufficient to move us forward toward a testing program by the early '90s, and for development by the turn of the century?

Dr. Colladay. I think it is, Mr. Walker. We are building up the budget with FY 1988 being the year that we're heavily into hardware fabrication. The big driver on the budget for FY 1988 is development of the engine systems, which we have to test at near full scale to provide enough information that we can, with confidence, make a decision to go forward with the X-30. But, the budget is sufficient.

Mr. Walker. That's the scramjet technology you are talking about?

Dr. Colladay. Yes, it is.

Mr. Walker. And when do you expect to have completion of the developmental phase of the scram jet?

Dr. Colladay. That will be in FY 1989.

Mr. Walker. In 1989. And under the present planning, when would that engine then be put into the X-30 and we could expect flight tests?

Dr. Colladay. 1993 is the planned date for the all-up airplane starting flight testing.

Mr. Walker. Originally some months back there was talk about having those flight tests by the 1991-1992 time period. Why the slippage?

Dr. Colladay. There has been some slip caused by the reduction in the FY 1987 budget in the Department of Defense.

Mr. **Walker**. So we didn't appropriate enough in 1987 to keep it on schedule?

Dr. **Colladay**. I think the program needed some adjustment, Mr. Walker, with accelerating the supporting technology in materials and computational fluid dynamics, so that we would have a better engine once it was developed and tested. I don't think it weakened the program. But there was a slip of some eight months as a result of that, and a slight restructuring of the program that accelerated the technology maturation.

Mr. **Walker**. Where are we with regard to development of the skinning of the craft, and will that technology be aboard of X-30?

Dr. **Colladay**. Advanced materials are required for the vehicle, and that's one of the major areas of emphasis in the technology maturation effort. We're right at the coupon stage of developing advanced materials that can go from the laboratory into sheet materials sufficient to build an airplane. That is one of the critical paths in the program. But we are making good progress in advanced metal matrix composites.

Mr. **Walker**. Are we also looking at innovative cooling techniques for skinning of the craft?

Dr. **Colladay**. We have done some testing on extremely lightweight heat pipes for leading-edge cooling, and that's the overall cooling, using hydrogen as an integral part of the airframe design that the contractors are looking at now.

Mr. **Walker**. Will the heat pipe technology be aboard the X-30?

Dr. **Colladay**. Yes. It would have to be.

Mr. **Walker**. And the question of the X-30 flight test pattern, are we going to be showing both the hypersonic capabilities as well as space insertion capabilities?

Dr. **Colladay**. It will go through an extensive flight test program that will start with hypersonic flight, but the vehicle will be designed to meet the principal goal of the program.

Mr. **Walker**. Dual purpose?

Dr. **Colladay**. Dual purpose, achieving orbit.

Mr. **McCurdy**. I don't want to interrupt the gentleman, but again I'd remind him that tomorrow at 11:00 o'clock we are going to have the joint hearing on the aerospace plane with Dr. Colladay and the DOD, with the R&D subcommittee of Armed Services.

Mr. **Walker**. I wasn't sure whether Dr. Colladay was going to be back at that point or not.

Dr. **Colladay**. Yes, I will be there.

Mr. **McCurdy**. I'm not trying to cut you off, Bob, at all, but, you know, we will have an opportunity to go into quite a bit of detail there, I hope.

Mr. **Walker**. That's fine, and I appreciate that. I wasn't sure whether Dr. Colladay was going to be back, and I was just trying to establish a base from NASA's viewpoint.

So from your perspective at the present time, there is sufficient funding in this year's budget and in what has been proposed for out-year budgets to complete the test pattern as you have described it here this afternoon?

Dr. **Colladay**. That's correct, Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. McCurdy. I thank the gentleman. And again, I certainly don't want to cut him off, but we are going to have a full-blown hearing tomorrow, which will be joint, which I felt was necessary to explore the—both the classified and unclassified elements of that program. I think it should be an interesting one.

The gentleman from Maryland?

Mr. McMillen. Mr. Chairman, I just have a follow-up to our previous question in regards to ceramics and composite technology. It was brought to my attention that Japan is investing between 100 million to $300 million annually in ceramics alone, in the public sector. My question, I guess, revolves around the fact that so much of our economic and national security is really reliant on this capability that in great deal is abroad.

How do you—how do you evaluate that? And what are we doing to prepare for it? What are we doing domestically to build a capability in the PAN precursors in the polymer area, and what are we doing to offset this dependency on foreign materials?

Dr. Colladay. Our investment at this point isn't, in sheer dollars, as you observed, keeping up with Japan's public funding. We do have the fundamental materials development covered reasonably well between Department of Defense and NASA. It is not robust and, if you carried the laboratory progress in advanced materials and processing in ceramics to the manufacturing level of processing in getting into turbine components, then the budget would have to go up proportionately.

There is no question that we're not, from the standpoint of dollar investment, matching the Japanese.

Mr. McMillen. One of my concerns, I guess, is that we are always accused in this country of being myopic and never having a long-term view of things, whether it's energy, whether it's—going down the line. What I'm concerned about is here is some technology where you clearly say that we are preeminent in our aerospace areas, in the regards that you discussed, and yet we could possibly lose our strategic advantages in these areas because we are not mindful of the tremendous investment at an order much, much greater that's being made by the Japanese and the Europeans in the composites and ceramics areas, and I think it is very, very important. We are spending paltry sums on these technologies even though, as I said before, they may result in an industry of a magnitude of 10, 12, $20 billion in just a few years. And I would just like to have more assurance that we're going down the right road.

As a newcomer to this committee, I'm not exactly convinced that we are.

Thank you.

Mr. McCurdy. Thank you, Mr. McMillen.

Again, the Chair shares your concern, and I think we will be having a separate hearing on materials policy, and that we will have an opportunity to—to raise those points with the Administration.

Dr. Colladay, your request highlights the need to rehabilitate and modernize many of the aging wind tunnels you talked about, the 12 foot tunnel that was 40 years old, or some 30 x 60 feet, 56 years old, the—got a couple in their mid-30s, one 45. It is not geriatics, but it's certainly getting close to middle age.

Why—how did this occur? I mean why—how did the problem arise, and how extensive is it, and are we all of a sudden going to be faced with a major bow wave that's going to be a cost, going to be an impediment to revitalize these tunnels?

Dr. COLLADAY. Those are the questions I was asking myself and as a result was prompted to start this national assessment of our tunnels, as well as considering industry and DOD. NASA holds a good share of this total national resource.

We maintain the tunnels in safe operating condition. We do the maintenance that's required to maintain safety. We have never experienced, until now, tunnels that wear out due to fatigue life. You are always faced with a dilemma at that point when you know that they are going to wear out, whether to pull an operating tunnel offline and repair it, like the 12 foot-or let it go to the point where you have to decertify it, if you will, to the point where it's no longer useful, and then shut down and repair it.

It's a concern to me, because when I look downstream at advanced vehicle developments, the demand is going up. The average age of our tunnels, as you observed, is getting up in years. The average is 32 years.

Most of our Construction of Facilities budget goes into modernization and repair and rehabilitation of existing facilities. Now that includes extended capability, like the 40 x 80 was rebuilt when we added the 80 x 120 leg and we repowered the drive motors. That's modernization, it's using the same shell, but it's extending the capability, too.

About 70 percent of our resources in Construction of Facilities goes into that category; 30 percent goes into the essentially new capability.

I don't know what the magnitude of our repair and modernization of facilities is going to be as a result of this study. If the 12 foot is any indication, we could be looking at a big problem here that will have to be addressed at the same kind of level that the Unitary Plan Act of Congress established in many of the tunnels in the first place.

Mr. MCCURDY. Has DOD done a comparable——

Dr. COLLADAY. They are supporting us in Tullahoma and are represented on our assessment committee. They are doing a study in parallel with us, in supporting ours. The Tiger Team have had two or three meetings. I have been pressing them to get an early report back to me so that I can get an indication whether it's a problem that I need to deal with in a supplemental or in the 1989 budget. It's scary.

Mr. MCCURDY. Well, it could be if there's this kind of programmed obsolescence. I mean if they all hit at the same time, it could be a major—a national resource that could be wasted here, and it could be a choke point for future development, and that's what we want to avoid.

In your budget, you have some 1988 $29.9 million for construction of facilities. Could you take just a minute to explain that?

Dr. COLLADAY. Yes, Mr. Chairman. That's what we call the discrete major projects construction of facilities; but, in addition to that, there's $19 million in minor programs for repair, rehabilitation modification, and minor construction.

The discrete programs in the FY 1988 budget that total $29.9 include the integrated test facility at Dryden which was split-funded over two years so that's the second year increment of a 1987 start project; modernization of hypersonic propulsion facilities at Langley; addition to the central computer building at Lewis Research Center; and, also, a modernization of Lewis' fan and compressor main central air system and control system.

So, of that, there's one new capability, the Dryden facility. The rest are what I'd call modernization and rehabilitation of old systems. The fan and compressor building at Lewis, for example, is at least 30 years old and has got an airflow control system that wanders through a test point when you're trying to do detailed flow measurements in turbomachinery. It's pretty tough to have the flow variation that exists with that archaic control system. So we want to gut that and go to a modern control system.

With the old kind of testing of turbomachinery, compressor and turbine testing, that maybe was adequate for steady state time average data. But, for the computational fluids verification experiments where we are trying to make detailed measurements in blade passages, it just won't hack it.

Mr. McCurdy. One of the many hats that I have to wear here as a member of the Military Construction Subcommittee in Armed Services, and since I'm new on this, I've been curious as to what procedures you undergo to validate your construction requirements, and what is just the general process by which you get your construction money?

Dr. Colladay. It's a very lengthy process, Mr. McCurdy. It starts with a preliminary engineering report that is essentially a preliminary design of every project that makes it in the budget for a given fiscal year. Then, an A&E firm is brought online, and we go through the preliminary design. We essentially know the cost of those facilities before they are ever requested of the Congress.

And very often, I will use R&D study money even before that preliminary engineering report to do a feasibility assessment for new capability that is needed. Very often, as a result of that, we will build a pilot tunnel and actually operate a small-scale tunnel, if the full scale facility is pushing the state-of-the-art. We did that on the cryogenic National Transonic Facility. We had a small .3 meter cryogenic tunnel that operated in pilot form before we ever decided we should go for the full-scale version.

Mr. McCurdy. Is there GSA review, or what is the review process? Is it just internal NASA hierarchy? Are they all—are they sole-source, are they competitive? How do you bid? Who does the control of the bidding process?

Dr. Colladay. They are competitive. The source selection is usually a facilities manager that's separate from the program management. General McGarvey is the director of NASA Facilities, and his office has the oversight and procurement responsibility. The program people are essentially advocates for the facility capability. They are separate.

Mr. McCurdy. You indicated earlier that the new rotor, fixed rotor technology—I guess that's, of course, the——

Dr. Colladay. The X-wing?

Mr. McCurdy [continuing]. The X wing—is going to have tests starting or commencing in May?

Dr. Colladay. That's correct.

Mr. McCurdy. How do you view that right now, and how promising is that? I mean is that something that will have general application other than military?

Dr. Colladay. I think it will have general application. It fills the range of the speed regime from the limitation of helicopters to the tilt rotor to the X-wing, all the way up to Mach .8 or .9, near transonic.

So, I think the application for the civil sector is there, just as we always felt it was for the tilt rotor, and I still believe it is.

Mr. McCurdy. We still have to get the Navy more involved in the V-22.

Dr. Colladay. In the V-22, operational experience, I think, will lead the way for the commercial sector. I hope the same thing happens with X-wing. It's just pushing out to the higher speed range. It's a tough technical challenge. You could support a career if you were in control disciplines with that vehicle. We're running up against a lot of the problems that we suspected we would have when we started the program. We had three principal technical challenges.

One was the composite rotor blade, and that proved to be more difficult than we thought but we got through that. The next was the control system, which, with the circulation control is a very complex thing.

Mr. McCurdy. I've seen the blade with all the little holes in it.

Dr. Colladay. The third is just the software and the flight control system itself.

Mr. McCurdy. I thought you would have said the clutch.

[Laughter.]

Dr. Colladay. Well, I lump that with the control system and the circulation control. But it's a long way from reaching flight status, and I think we're going to have our work cut out for us in the flight program. We've got a year-plus planned for the flight phase, and we are going to go through it very carefully as we approach the transition, which is the objective of the RSRA flight vehicle.

Mr. McCurdy. What is your view of the priority of the proposal to treat Langley's 4 x 7 meter tunnel with acoustic tiles, to allow for noise testing of rotorcraft and transport aircraft? And again, I always liked the definition of helicopter as a machine that beats air into submission.

[Laughter.]

Dr. Colladay. Well, that's close to the one that I remember of how a helicopter flies. It's started up and it shakes and rattles and beats and makes a hell of a racket until the earth rejects it.

[Laughter.]

Mr. McCurdy. Imagine what it does in a wind tunnel.

Dr. Colladay. The 4 x 7 meter tunnel is a workhorse aerodynamics facility. We did have a construction project in 1983, where we acoustically treated the large open test section, but not with the anechoic treatment that the rotorcraft industry would like us to do. That has been studied in great detail by Langley for the last three years, and I know the rotorcraft industry would very much like to have that capability in the U.S. instead of having to go to DNW to do their acoustic testing. And I think we'll do it eventually. The question is the priorities with other construction projects—and the need to address this concern about repair and modernization and where it fits in the priorities for FY 1989. I haven't decided yet. It depends on how big a problem I see we have in the integrity of our existing facilities. It's an important thing to do and I believe our industry is right in saying that we ought to have that capability in the U.S.

Mr. McCurdy. Are there any other—back in the '70s, we achieved some choke point or we saw some choke points in just general aviation technology and manufacturing with the critical materials, and the fact that you had only one or two forges that were large enough to handle some of the requirements.

From a general aeronautics standpoint, are there—what are the choke points of the future? Where are they now, and where are they likely to be? When I look at your R&D goals, you are talking in a fairly general sense of the different requirements. But I was just curious if there had been any work done in identifying—I guess that lead technology that's going to hold us up or send us over the hump later.

Dr. Colladay. The answer to that in part depends on how real you think high speed flight and supersonic commercial or even hypersonic and hypersonic cruise for military and civil aircraft is. That represents a whole set of technologies that are right to be advanced in high-temperature materials alone. With the kind of breakthroughs that the National Aero-Space Plane is going to require in advanced metal matrix composites, we could advance vehicles, both spacecraft and aircraft.

I think materials has always been a long pole. It still is. I think we are at the point where, with proper investment in and advances in high-temperature engine materials, we can eliminate cooling air which is such a penalty to the overall engine cycle and, as a result, get a step change in engine performance.

So both airframe and engine materials, I think, are high leverage technology areas.

If I look at the R&D process that we pursue in this country, I think we're investing adequate resources in fundamental laboratory research. If you look at the whole chain of the R&D process, where we seem to fall down in getting our technology out of the laboratory and applied is in the validation of the laboratory technology in realistic full scale environments, whether it be experimental engines or experimental vehicles. We have seen time and time again, until you take that step, industry is reluctant to invest the huge resources required to develop new products. And I think NASA needs to look hard at the policy that was established in the early 1980s about the role that we play in every step of the R&D process, from laboratory to validation.

Now I make a distinction between validation and demonstration. The Administration policy says that for civil applications, NASA's role stops short of demonstration. And I can live with that, providing I am allowed to define validation as a step just short of that. I think it makes sense to do that. Validation is where you're still doing research, you're still learning and developing technology, but you're doing it at realistic scale and in realistic environments.

Demonstration, to me, is where you're sure what the result is going to be, and you're just proving it to the market or to those that might be interested in seeing products developed downstream.

The advanced turboprop program, for example, to me is validation of technology, taking the small scale wind tunnel results and doing research on essentially a flying wind tunnel which downstream is validating the concept that at realistic scale. That's an important step in the R&D process, and when funds are limited, that's what usually gets eliminated or scaled back. You can't have that without the underlying foundation. So, in limited funding, you tend to address the fundamental laboratory work which we have done.

Mr. McCurdy. What has your experience been in the recent development and expansion of CAD/CAM and the CAM system and all the computer system manufacturing and design? You have thrown away the old tables, you know, the drafting tables, where people laboriously worked for hours and hours, and now you are doing it all on computer. And of course, we spent millions of dollars on computer facilities, and it almost appears to be total reliance on that. How much difficulty has there been in the actual transferring of that—those design tests to the application phase? In other words, we fly it on computer long before we ever have a model of it, and I have flown simulators of systems—I won't say what they are in this forum—but I have flown simulated systems before they have ever been, you know, a piece of metal, and they say this is how we envision what the flight envelope will be, and the way it flies and all that, and I crashed a simulator, but, you know, I——

Dr. Colladay. Better that, than the real thing.

Mr. McCurdy. In developing the—you know, how much gap is there, how realistic is that? Are we relying on that too much? Have we found—there's a big push in R&D for concurrency. Of course, we found it to be that concurrency didn't operate too well.

From your standpoint, from an aeronautics standpoint, is there too much reliance on that computer? Is there too much concurrency?

Dr. Colladay. In general I don't think so, Mr. McCurdy. That's what lets us do more than we could with the limited budgets that we have in dealing with more complex systems, but that doesn't take the place of experimental vehicles. You still have to validate the simulators. You still need the experimental data base.

We can do things more efficiently. We can come closer to a more effective experimental program designed to closely optimize or more nearly optimize performance, with all of the computer-aided design and manufacturing tools, but there's no substitute. You can't exist in a virtual world where we do everything by computer. If that is married closely with a well thought-out experimental program, then I think the combination is powerful.

In some respects, a similar question often is asked about the Numerical Aerodynamics Simulation capability. Will it put wind tunnels out of business? And while some people have said yes, my answer to that is absolutely no. It will change the way we use wind tunnels. We'll get a lot more out of wind tunnels by being able to numerically simulate the flow field around models so that when we do build a wind tunnel model that it's closer to the design that we want rather than build a whole series of them.

But I think in general CAD/CAM has let us do things that we'd never be able to accomplish, even in the research program, not just in manufacturing and development. We're using it to compress the time scale between a concept that exists in the researcher's mind to when he has a model that he can put in the wind tunnel.

Mr. McCurdy. On an unrelated subject I know I'm shotgunning you here, but I don't have an opportunity to have it all to myself to get things on the record.

Recently I had some people in your office, I think meet with engineers regarding an internal wing design that was patented. I don't know if they've met with him or not, but there's some point we're going to have you meet with him, because there has been some controversy over that, and there's a country that actually has a patent on a design that—you know, it's a small group, and they're dealing in the world of the giants, and whether it's a NASA or a aerospace company, there aren't any aerospace companies, and sometimes they like to either, you know, add the NIH syndrome that wasn't really there, and I'd be interested in getting some realistic evaluation of the concept, and whether or not it makes sense, perhaps help us direct a way to—to protect the small innovative firms and companies that are coming up with ideas that may appear crazy at first blush, but I'm particularly interested.

This one happened to be an Oklahoma firm, it wasn't in my district, but they came to me with an idea, and I understand their problem. You know, they want to keep the technology, the idea, but at the same time, they have to play with big guys, and sometimes NASA doesn't want to. You like—you know have issues of proprietary rights and all of those that you have to deal with, and I'd like for you to evaluate that concept and report back to the Subcommittee at some point.

Dr. Colladay. We will be happy to do that.

Mr. McCurdy. We'll be getting into it. And Mr. Crossfield and others have been working on it. Again you know, I'm not the engineer, I'm just saying I like to have a free flow of ideas and hope that that's part of your motto also.

Mr. Greene, do you have any questions on the line that Mr. Lewis has that you can feel free to ask at this point.

Mr. Greene. Thank you, no. Maybe submission of questions for the record.

Mr. McCurdy. Okay.

Mr. Greene. Thank you.

Mr. McCurdy. We'll have those and try to keep those short. Any other points that we need to cover while we've got him on tape? If not, we will see you tomorrow at 11:00 for the joint hearing, and appreciate your testimony today.

Dr. Colladay. Thank you, Mr. McCurdy.

[The prepared statement of Dr. Colladay follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

MARCH 10, 1987

STATEMENT

OF

Dr. Raymond S. Colladay
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Transportation, Aviation and Materials
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I am pleased to present NASA's FY 1988 Aeronautics and Transatmospheric Research and Technology (R&T) budget request which reflects a continuing strong commitment to research and technology. Our program continues to be focused on long-term, emerging technologies aimed at maintaining United States leadership in aviation and enhancing U.S. industrial competitiveness.

Last year I described some major contributions that I expected from the program for the coming year. Indeed, 1986 was an outstanding year for NASA's aeronautics program. Before I discuss the FY 1988 budget request, I would like to briefly describe some of these achievements.

In the area of computational capability, the Numerical Aerodynamic Simulation (NAS) facility at NASA's Ames Research Center began initial operations on July 21, 1986. Construction of the new NAS building is complete (Figure 1) and the entire complex was formally dedicated on March 9, 1987. The capabilities of the NAS are already in high demand and there are currently over 190 remote users throughout the U.S., tied in by the NASA Program Support Communications Network (PSCN). Through this broad user network, the NAS computational power is being applied to perform many complex aerodynamic, structural, and materials calculations that were not previously possible. For example, solutions for viscous 3-dimensional flows about complete aircraft configurations are now possible. The particle streamline traces from a representative calculation for an F-16 aircraft configuration are shown in Figure 2. Similar calculations are also being performed to examine the internal flow field (Figure 3) of high-temperature turbine engines. The NAS capabilities are being used extensively in the National Aero-Space Plane (NASP) program to allow the analysis and prediction of the aerodynamics (Figure 4) and aerothermodynamics at flight conditions where ground test facilities are not available. The advances in computational capability with the NAS have also been applied to support the NASA Shuttle Solid Rocket Booster redesign effort with advanced structural modeling and analysis (Figure 5).

In the area of experimental capability, the new National Transonic Facility (NTF) at NASA's Langley Research Center was used for development testing as well as for fundamental aerodynamic research during 1986. At the request of the Navy, NASA developed and tested aerodynamic modifications that could significantly improve the safety and effectiveness of the Navy's EA-6B electronic countermeasures aircraft. (Figure 6). The NTF was also used to test a Shuttle configuration model in the ascent configuration (Figure 7) in order to examine the effect of the booster plume on orbiter wing loads.

Laser velocimeter instrumentation technology was used in the 14- by 22-Foot Tunnel at the Langley Research Center during the past year to obtain the first nonintrusive, time dependent, detailed flow-field data in the rotor plane of a helicopter model (Figure 8). The results are being used to validate improved rotorcraft design methods.

In aerodynamics, major strides were made during the last year in developing the technology for drag reduction using natural laminar flow, laminar flow control, and turbulent drag reduction methods.

A full size proof-of-concept wing was designed by the Langley Research Center and fabricated by the Cessna Aircraft Company under a cooperative agreement. Flight and wind tunnel testing (Figure 9) on a modified Cessna 210 aircraft validated the predicted 70 percent extent of natural laminar flow. Flight testing was initiated on an F-14 aircraft modified with natural laminar flow gloves on the upper-surface of the variable sweep wing (Figure 10). These experiments extend our knowledge of boundary layer transition for wing sweep angles and flight conditions representative of future transport aircraft. Flight tests of a modified NASA Lockheed JetStar with active laminar flow control leading-edge gloves (Figure 11) have demonstrated that laminar flow control can be maintained in a realistic airline environment without any undue maintenance burden. Future research efforts will concentrate on hybrid laminar flow control (HLFC) which combines natural and active laminar flow control to obtain significant drag reduction benefits with minimum system complexity.

The skin friction drag reduction benefits predicted for riblets (tiny longitudinal grooves on the surface) were measured in detailed flight experiments (Figure 12) performed at the Langley Research Center on the fuselage of a Learjet aircraft. These tests measured a 6- to 8-percent reduction in skin friction drag. This is the same riblet technology that was licensed to the 3M Company and used to reduce hull drag on the winning America's Cup challenger "Stars and Stripes". NASA-developed analysis methods also played a critical role in the hull and rudder designs.

Another method for obtaining improved aerodynamic performance was demonstrated during the past year with flight testing of the variable camber mission adaptive wing on the NASA/Air Force AFTI/F-111 aircraft (Figure 13). Test results for the in-flight manual pilot adjustment phase of the program have demonstrated improvements of 25-30 percent in mission range and 15 percent in sustained maneuvering G's when compared to the F-111 aircraft with a supercritical wing. Research will begin this year on an automatic variable camber system.

In order to further enhance the maneuvering capability of high-performance aircraft, NASA has continued to pursue research for vehicle control at very high angles of attack. Wind tunnel tests have been conducted (Figure 14) to investigate the aerodynamic characteristics and flow fields at post-stall conditions. In addition, free flight tests have been conducted in the 30- by 60-Foot Tunnel (Figure 15) at the Langley Research Center to evaluate the effects of propulsive control on the stability/control and handling qualities of the DARPA Enhanced Fighter Maneuverability research aircraft concept. Modifications of an F-18 are underway in preparation for high angle-of-attack flight research.

In propulsion, NASA's pioneering efforts in developing the technology for new fuel-efficient, high-speed propellers have led the way for the industry to develop a new generation of propulsion systems. The Unducted Fan (UDF) concept, developed by the General Electric Company, is a unique counter-rotation turboprop design that couples the propeller blades directly to the turbine to eliminate the need for gears. The UDF engine, under contract to NASA, successfully completed ground testing during August 1986. Flight tests are currently being conducted by General Electric with the engine installed on a modified Boeing 727 aircraft (Figure 16). Additional flight tests will be conducted later this year on a modified McDonnell Douglas MD-80 aircraft.

During the past year, wind tunnel testing was completed on a model of the modified Gulfstream II aircraft (Figure 17) that will be used for NASA's Propfan Test Assessment (PTA) program. Modifications were also completed on the flight test aircraft (Figure 18) and flight testing will begin this year. The results of the PTA flight tests, combined with the UDF tests, will provide a significant advancement in the technology for high-speed turboprop propeller design that can be used as a basis for future industry decisions on advanced turboprop systems, whether they are single- or counter-rotation and tractor or pusher configurations.

In another speed regime, as a part of the NASP technology maturation program, NASA has designed a variable geometry scramjet inlet as part of the effort to explore various approaches to achieving lighter weight hypersonic engines. A model of this inlet (Figure 19) was successfully tested at Mach 4 and will be tested over a wide range of Mach numbers this year to determine the suitability of the concept. Also during the past year, fabrication was completed on a fuel injection side strut test article designed for the harsh temperature environment of a scramjet engine. This strut will be tested under realistic operating conditions in the Langley Research Center propulsion test facility this year.

During the past year, the NASA F-15 Research Aircraft (Figure 20) began flight testing of Highly Integrated Digital Electronic Controls (HIDEC). Initial flight research in the HIDEC program has verified the performance improvements predicted for an advanced adaptive digital engine control system, which uses flight path information to trade off engine stall margin for increased thrust or reduced fuel flow. For the test aircraft, with only one of the two engines modified with the HIDEC installation, the total thrust was increased up to 10 percent and the fuel flow was reduced by up to 14 percent.

In support of the FAA and as a part of NASA's research efforts in aviation safety, a major mission simulation study of the human factors aspects of the new Traffic-alert and Collision Avoidance System (TCAS II) was conducted at the Ames Research Center during the last year. The TCAS II provides information in the cockpit, illustrated in Figure 21, on the position and threat potential of three aircraft in close proximity to the subject aircraft.

Commercial airline crews flew full mission scenarios in which collision avoidance was required. The results have provided information on display effectiveness and pilot response. The new Advanced Concepts Flight Simulator (Figure 22) is now operational and being used for additional human factors research of highly automated flight systems. During the past year, this simulator was used to conduct joint research projects on side-stick control systems with both Douglas and Boeing.

As a part of NASA's windshear research program, conducted in association with the FAA, a computer model was developed that uses aircraft flight recorder data to compute the wind patterns affecting an aircraft. The wind patterns resulting from these computations have been used in accident investigations, in developing forecasting models, and in simulations used for pilot training and for developing aircraft detection systems. Research is continuing this year aimed at developing airborne windshear detection systems and in another weather related area, investigating the effects of heavy rain on aircraft aerodynamic performance.

NASA wind tunnel research on airfoils conducted with extremely heavy simulated rain conditions (Figure 23) has shown reductions in maximum lift and increases in drag. To obtain information on extrapolating these small-scale wind tunnel results to flight, ground tests of a full-scale airfoil will be conducted this year using the Aircraft Landing Dynamics Facility at the Langley Research Center.

The X-29A (Figure 24) completed envelope clearance flights at the NASA Dryden Flight Research Facility and follow-on research has been initiated. The technical results of the envelope expansion phase of the program will be presented to the U.S. industry later this year. Future research efforts will focus on the high angle-of-attack regime.

In rotorcraft technology, the X-Wing concept, which offers the potential for combining the vertical takeoff and landing capability of a helicopter with the high cruise speed capability of a fixed-wing aircraft, reached a major milestone last year with the completion and rollout of the NASA/DARPA RSRA/X-Wing aircraft (Figure 25). The vehicle is in final checkout in preparation for the start of the flight program at the Dryden Flight Research Facility this year.

NASA aeronautics research resulted in many outstanding achievements in FY 1986, and this record of accomplishment is expected to continue and grow in FY 1987. In striving to maintain an aggressive and forward looking program of aeronautical research and technology in FY 1988, NASA has continued to focus on emerging technologies with high payoffs. The FY 1988 NASA Aeronautics and Transatmospheric R&D budget request is shown in Figure 26 compared with the previous year's budget. The total Aeronautics budget request for FY 1988 is $375.0 million, a $10 million increase over the projected FY 1988 level of last year, which was showing a downward trend due to the completion of several successful programs. This year's Aeronautics R&D budget request continues the progress made last year and enables us to move forward into several new areas--all consistent with a plan of action for achieving the National Aeronautical R&D Goals. Three of these areas that I would like to highlight are high-temperature engine materials technology, facilities modernization and high-speed transportation studies.

The high-temperature engine materials program represents a consolidation and expansion of the previous hot-section technology and the ceramics for turbine engines programs. Progress in high-temperature materials presents an opportunity for dramatic improvements in engine thrust-to-weight ratio and efficiency by allowing increases in turbine inlet temperature (Figure 27) without cooling of the turbine blades. With the progress made in the laboratory recently, this area shows extremely high promise for making a tremendous advance in propulsion over the next 5-10 years. Better high-temperature materials are particularly important for the engines in supersonic cruise and short takeoff and vertical landing (STOVL) aircraft, but they apply to every class of engine. Research will be directed at ceramics, ceramic matrix composites, metal matrix composites and carbon-carbon materials for high-performance gas turbine engines building on the work that has been ongoing in the R&T base and the hot-section technology and the ceramics for turbine engines programs. This will include the development of new fibers, matrices, and processing techniques for the fabrication of ceramic-matrix composites and metal-matrix composites. Coatings for fibers, composites, and carbon-carbon materials will also be developed.

NASA is responsible for a large number of major aeronautical facilities that are essential to maintaining U.S. superiority in aeronautics. These facilities are experiencing, and will continue to experience, significant increases in demand to support the new aircraft development programs, to conduct experimental research on new concepts, and to provide the detailed experimental data base necessary to validate new computer prediction methods. Many of our major wind tunnels are getting old and in need of rehabilitation and modernization. We have initiated a comprehensive assessment of projected national wind tunnel utilization and the state/adequacy of existing major NASA wind tunnels to meet the demand. This assessment will form the basis for developing a time-phased, prioritized plan for providing new capability and modernizing and rehabilitating the highest priority facilities. As part of the study, we will also look at removing facilities from active status, if appropriate. In addition, a wind tunnel efficiency enhancement initiative will be directed at increasing the productivity and quality of the test data for these critical wind tunnels--with improvements in data systems, displays, and instrumentation.

The supersonic goal remains a great opportunity that's yet to be exploited. During this past year, NASA embarked on major high-speed transport studies with the industry to examine the market opportunities and determine the economic, environmental, cruise speed, size, range and fuel characteristics necessary to become a successful element in international air transportation. The studies will identify the most promising aircraft concepts and define the necessary research and technology efforts. NASA is working within the aeronautics community to establish a consensus and strategy for high-speed transportation before coming forward with the technology program required to support a U.S. industry initiative in this area. In the meantime, a small but growing effort in the critical technology areas is being maintained.

NASA has historically maintained a productive program in the critical technology areas of propulsion, propulsion/airframe integration, and high-temperature structural concepts for hypersonic applications. These activities have now become more focused and will continue to pursue long-term technology advancements that are applicable to the National Aero-Space Plane program and to a broad range of future hypersonic vehicles.

The emergence of technology in hypersonics R&T in NASA and in other U.S. government laboratories and industry has led to the promise for a new class of aerospace vehicles which can travel at hypersonic speeds up to orbital velocities using airbreathing propulsion and airplane-like operations. These advances include demonstrated performance of airbreathing supersonic combustion ramjet (scramjet) engines; advances in high-temperature, lightweight materials and structural concepts; and the availability of supercomputers such as the Numerical Aerodynamic Simulation capability at the NASA Ames Research Center. Launch vehicles based on this technology would be able to take off and land on conventional runways and fly directly into orbit, providing an important option for space transportation in the next century. Alternatively, a hypersonic aircraft could provide point-to-point intercontinental travel as a high-speed transport or military surveillance vehicle. As mentioned earlier, NASA has initiated high-speed civil transportation studies with industry that include consideration of that class of vehicle.

NASA has joined with the Department of Defense (DOD) to conduct the National Aero-Space Plane (NASP) program. This program is a combination of vehicle design and component development and testing and a supporting technology maturation effort. It is an outstanding example of the blending of aeronautics and space technologies and has enlisted a highly skilled national team from government, universities, and industry. The NASP program is a primary component of continued world leadership by the United States in aerospace technology.

To conduct the NASP program, the NASA and DOD have formed a joint program management organization (Figure 28) that includes a Steering Group with the Under Secretary of Defense (Acquisition) serving as chairman and the NASA Associate Administrator for Aeronautics and Space Technology serving as vice-chairman. The program is being implemented through the Program Management Office located in Washington, D.C., and Joint Program Office located at Wright Patterson Air Force Base. NASA has established a NASP Office in OAST to coordinate the NASA activities.

The NASP program is comprised of the three phases shown in Figure 29. The first phase, which dealt primarily with concept feasibility, was completed in 1985 and provided the confidence to proceed with the program last year. The second phase, which deals with technology development, is currently underway and scheduled for completion at the end of 1989. This phase includes five competing airframe contractors, three competing propulsion contractors, and highly focused technology maturation efforts. The five airframe contractors are Boeing, McDonnell Douglas, Lockheed, General Dynamics, and Rockwell. The three propulsion contractors are Pratt & Whitney, General Electric, and Rocketdyne. Rocketdyne is participating in the program with its own funding at this time. The competitive contract efforts include conceptual and preliminary design, component development, and testing. The technology maturation effort includes research at NASA centers, other government laboratories, and industry efforts in generic areas supporting all of the contractors. The decision to proceed to Phase 3 will depend on an assessment of technology readiness in 1989 by the NASP Steering Group. Phase 3 will develop and flight test the X-30 research vehicle.

NASA is requesting $66.0 million for Transatmospheric R&T, to be combined with $18.0 million from the Aeronautics and Space R&T Base budgets for a total of $84.0 million in FY 1988, as its share of the joint DOD/NASA National Aero-Space Plane program. The DOD is requesting $241 million and the combined request is shown in Figure 30. The budget growth reflects the fact that next year we will begin fabrication of proof-of-concept engine systems for full-scale ground testing up to Mach 8 as one of the key milestones for the future X-30 experimental vehicle. It also reflects a continued strong technology maturation effort to insure the timely development of critical technologies.

Significant technical progress is being made in a number of critical technology areas, including propulsion, materials and structures, and computational fluid dynamics. Specifically, NASP program tests conducted in the NASA Langley Research Center Propulsion Wind Tunnel have demonstrated the successful operation of a candidate ramjet engine cycle under conditions corresponding to a flight Mach number of 3.5 (Figure 31). In addition, they have achieved good agreement between the tunnel test results and analytical calculations for the engine cycle.

A hypersonic engine model was also tested at the CALSPAN Shock Tunnel at a flight Mach number of 10 (Figure 32). This model is a derivative of the NASA Langley Research Center airframe integrated scramjet design. Tests included combustion with varying fuel/air ratios and varying fuel injection angles and the use of downstream fuel injection along the engine walls to reduce wall heating and skin friction. The tests demonstrated good combustion efficiency and resultant thrust for the short combustor section used. The tests showed, as predicted, a marked reduction in skin friction with film cooling. This reduction in skin friction is important in achieving the required engine system performance.

A number of different hypersonic inlet concepts are being evaluated in the program, such as the one recently tested in the NASA Ames Research Center Arc-Heated Wind Tunnel (Figure 33). In these tests, the free stream flow conditions were Mach 8 at simulated altitude of 200,000 feet and temperatures of 1400 degrees Fahrenheit.

High skin temperatures underscore the importance of developing lightweight, high-temperature materials for aerospace plane structures. This is one of the most critical challenges in the program. It is an area in which NASA has considerable interest and expertise and is working closely with DOD laboratories and industry. Major efforts are underway at the NASA Lewis Research Center in the development of fiber-reinforced composites for airframe and engine applications and at the NASA Langley Research Center in the development of carbon-carbon materials and advanced metal matrix composites for airframe applications.

Another important materials area being considered involves rapid solidification rate (RSR) processing. In this process, small droplets of molten alloys are spun off a disk and through a cool helium gas, cooling the droplets at rates up to a million degrees per second. This rapid cooling freezes in the alloy characteristics which would be lost in a slower cooling process. The resultant powder is then compacted under high pressure into sheets and other shapes. The resulting alloy can have up to twice the strength and stiffness of conventional alloys and retains its properties to much higher temperatures.

RSR titanium alloys being developed by this process are being further improved through the addition of fibers which will further increase the material strength and stiffness. The material shown in Figure 34 was created by plasma deposition of RSR titanium onto silicon carbide fibers. The resulting advanced metal matrix composite has two times the stiffness and one and one-half times the strength of the conventional RSR titanium alloy.

At the Ames Research Center, the 3.5-Foot Hypersonics Research Tunnel has been reactivated to support the NASP program. A hypersonic model is being used to obtain experimental data to validate some of the latest computational fluid dynamics codes. Figure 35 shows the model in the wind tunnel at flow conditions of Mach 7.4. Some initial CFD calculations have been completed to predict the Mach number contours on the surface of this model. These results are shown in Figure 36. Such calculations will allow the analysis and prediction of hypersonic vehicle aerodynamics and aerothermodynamics at flight conditions where ground test facilities are inadequate.

During FY 1988, two or three of the original five airframe contractors and two of the propulsion contractors will be working toward completion of Phase 2. These contractors will be identified by a competitive selection process near the end of FY 1987. Also, during FY 1988, two engine test facilities will be modified to allow propulsion system testing up to Mach 8. Emphasis will continue in the technology maturation area on the testing of subscale scramjet engine concepts, on the development of advanced materials and structural concepts, and on the validation of CFD codes. Special emphasis will be placed on boundary layer transition. The ability to predict transition accurately is critically important in heat transfer analyses for NASP vehicles. In addition, research on integrated controls will be continued.

Overall, the NASP program is making good technical progress. The program goals are still valid, though extremely challenging. An integrated DOD/NASA management team is in place and functioning well. Confidence is high and the NASA/DOD team will continue moving aggressively to achieve the NASP goals.

The R&T efforts in Aeronautics and Transatmospherics depend on a solid foundation in the long-term discipline research which forms the basis for future technology advancements for conventional subsonic transports, general aviation, helicopters and military high-performance aircraft. The FY 1988 budget request maintains NASA's research at the cutting edge of technology and provides for the continued close working relationships with industry, universities, and other government agencies. The following discussion describes the key elements of the Aeronautics R&T base program, emphasizing the important directions for FY 1988.

The aerodynamics program is focused on improving the understanding of basic aerodynamic phenomena, creating improved analytical and prediction techniques, and developing and validating advanced aerodynamic concepts. The remarkable progress made in computational fluid dynamics (CFD) in developing numerical simulation analysis and prediction methods for aerodynamic flows about complete subsonic and transonic aircraft is currently being extended into the supersonic and hypersonic flight regime with the inclusion of equilibrium and nonequilibrium chemistry. To support the development of advanced CFD application codes, the validation program will be expanded to meet the increasing need for high quality benchmark experimental data. Additionally, the Center for Turbulence Research, initiated in FY 1987, will expand its activities to increase the fundamental understanding of turbulence, turbulent flows, and, most importantly, provide critically needed data and ideas to advance turbulence modeling for inclusion in CFD computer codes. The Numerical Aerodynamic Simulation (NAS) program moved into its new building and began full operation of its initial operating configuration in FY 1987. During FY 1988 a second high-speed processor will be integrated into the NAS system to provide needed additional capability to conduct pathfinder large-scale CFD research and development in support of expanding programs such as the National Aero-Space Plane. Two additional areas to be emphasized in FY 1988 are drag reduction and helicopter flight dynamics. Research results on natural laminar flow and laminar flow control for skin friction drag reduction show high promise that both can be combined into a hybrid laminar flow concept. Research efforts over the next two years will focus on flight research and evaluation as a full chord section on a large transport aircraft. In helicopter flight dynamics, the need for increased maneuverability in air-to-air combat and nap-of-the-earth flight has led to increased research to define design requirements and to provide new concepts for control augmentation. Key to this activity will be the development of a variable stability helicopter by the Army for a joint flight research program.

The materials and structures program provides the technology base for advanced structural materials and concepts, analytical methods, and experimental validation for future airframe and engine systems. The emphasis in FY 1988 will continue to focus on high-speed aircraft requirements because they place the greatest demand on new materials development. The program augmentation in high-temperature engine materials will lead to major improvements in the performance of gas turbine engines. Airframe materials research will emphasize structural concepts and the testing of innovative hot structures using fabrication and material processing approaches necessary to achieve low weight fraction. Also, composites research will focus on concepts for tough, lightweight structures including 3-dimensional weaving and pultrusion methods for integrally stiffened panels, and interleaving "soft" material near structural discontinuities to prevent delamination. Multidisciplinary analyses and optimization will continue in FY 1988 as an area for further investigation. Aeroelasticity research on highly flexible, lightweight airframe structural concepts will focus on the control of flutter and flight instabilities during high maneuver loading over the entire flight regime encountered by advanced high-performance aircraft. Rotorcraft activities will continue to emphasize airloads, structural dynamics, and noise with the goal of validated design capability for rotorcraft noise and vibration reductions of 80 percent.

Propulsion research is focused on tools and analytical methods that will provide the basis for advanced engine components and propulsion systems. In computational fluid dynamics for flow in engines, methods are being developed for analysis of complex 3-dimensional flows in high-speed inlets and nozzles, turbomachinery, and chemically reacting flows. Experiments will be performed using nonintrusive instrumentation to develop a data base for code verification of complex flows such as those found in radial flow turbomachinery. Research will continue in FY 1988 on a 2-dimensional Mach 5 inlet, an ejector system for powered lift, and a supersonic throughflow fan concept for sustained supersonic flight. The results of these experiments will be used to verify 3-dimensional viscous analysis and design codes.

The propulsion systems technology program includes the Advanced Turboprop (ATP) and the GA/Commuter Engine technology programs. Emphasis in the ATP program is on completion of the large-scale flight tests required to verify scale effects on blade structures, aerodynamics, and acoustics. The flight test will also provide data for verification of enroute noise models and an evaluation of an advanced treatment concept for control of noise in the cabin. ATP supporting technology efforts will include analytical and small-scale experimental research for source noise, cabin environment, installation aerodynamics, and advanced blade structures for both single- and counter-rotation propellers. The GA/Commuter Engine technology program will emphasize evaluation of advanced components for small turbine engines.

The internal flow field of a large low-speed centrifugal compressor will be studied to determine secondary flows and end wall effects. Advanced compact and cooled radial turbines and a radial outflow combustor will also be evaluated for flow characteristics and performance.

Research in information sciences, controls and guidance, and human factors is focused on developing technology for aircraft automation, aircraft based windshear detection and avoidance, and flight envelope expansion for high-performance aircraft. Aircraft automation research is characterized by a blending of advanced controls technology and human factors with emerging artificial intelligence methodology in order to achieve a much more highly integrated human/computer system. Transport related applications of automation which are being investigated include intelligent aids for the pilot in the cockpit and for the controller on the ground in order to improve safety and efficiency and to facilitate the integration of aircraft in the National Airspace System. Rotorcraft applications of automation will be investigated to provide automated, single pilot nap-of-the-earth flight. This element of the program will result in the development of tools and methods for validating expert-system based flight controls. In conjunction with the Federal Aviation Administration, the technology for airborne radar windshear detection systems is being developed. Greatly expanded flight envelopes for high-performance aircraft are being pursued through advanced integrated subsystem and control law design, including use of thrust vectoring for primary control and reconfigurable controls.

Research in human factors is focused on highly augmented cockpits with the goals of enhancing crew/system interaction, increasing flight crew efficiency and improving safety. Specific activities include field studies of human error and distraction in highly automated commercial transport cockpits, and full mission evaluation of flight crew use of the Traffic-alert and Collision Avoidance System (TCAS). The Aviation Safety Reporting System (ASRS), a national repository for aviation incident reports, continues to provide a valuable source of information used to identify safety issues that need to be addressed.

In the flight systems program, analytical, wind tunnel, and simulator research is being conducted to evaluate advanced control concepts and to develop and refine the design tools and predictive techniques to enable high agility at all flight conditions. Systems studies and ground-based analytical and wind tunnel model investigations are also underway to identify the most promising aircraft and propulsion concepts for a potential advanced supersonic research aircraft capable of short takeoff and vertical landing. These contract studies and in-house research efforts are being conducted in cooperation with DOD and the United Kingdom. The NASA/DARPA/Air Force X-29A Forward Swept Wing experimental aircraft is providing critical data to validate the performance benefits from the integration of advanced technologies into a fighter aircraft configuration. The joint NASA/Air Force/Grumman flight test team is continuing testing of the first aircraft at angles of attack up to 20 degrees. NASA is modifying a Navy F/A-18 aircraft to a research configuration for flight research at high angles of attack for correlation with ground-based results. Research is also continuing to develop advanced design concepts and to validate significant performance improvements predicted for integrated propulsion/flight controls, addressing both conventional and short takeoff and vertical landing configurations.

Summary

The U.S. aerospace industry, and the aeronautics sector in particular, is the premier example of American industrial leadership. The trade surplus of $11 billion in 1986 was the highest of all U.S. export sectors. The technical excellence of our military aircraft continues to enhance global security. This American leadership has not happened by accident. It is the result of a highly successful industry, government and university partnership that has evolved since the founding of the National Advisory Committee for Aeronautics (NACA) over 70 years ago. The technology that has been developed through this partnership has been the cornerstone of our leadership in aeronautics. Recent examples of the power of advanced technology are evident in the successes of the "Voyager" nonstop, unrefueled, around-the-world flight and the "Stars and Stripes" America's Cup challenger.

The Office of Science and Technology Policy publication entitled, "National Goals for Aeronautical R&D: Technology for America's Future" and the recently published "Agenda for Achievement" outline enormous opportunities for dramatic advances in technology that could reshape aviation by the turn of the century. Pioneering new technology remains the highest leverage investment to insure American competitiveness. As we look ahead at the goals identified in the "Agenda for Achievement", it is clear that there is much to do.

We are not the only country to recognize these opportunities--our aeronautics industry is facing increased competition as never before. Other nations now dominate the world commuter aircraft market, account for nearly half the sales of rotorcraft, and are achieving significant market penetration in the large commercial transport market. Fortunately, the expertise represented by the government, industry, and university partnership is unsurpassed anywhere in the world. Maintaining the vitality of this partnership is essential.

Recognizing the pivotal role of developing technology for America's future, we have focused the NASA Aeronautics and Transatmospheric R&T program to concentrate our efforts on the technologies that offer the highest potential payoff. The achievements from this program that I have described for FY 1986 demonstrate the effectiveness of our research efforts.

Thank you, Mr. Chairman. That completes my prepared testimony. I would be happy to answer questions.

NUMERICAL AERODYNAMIC
SIMULATION FACILITY

Figure 1. Numerical Aerodynamic Simulation Facility

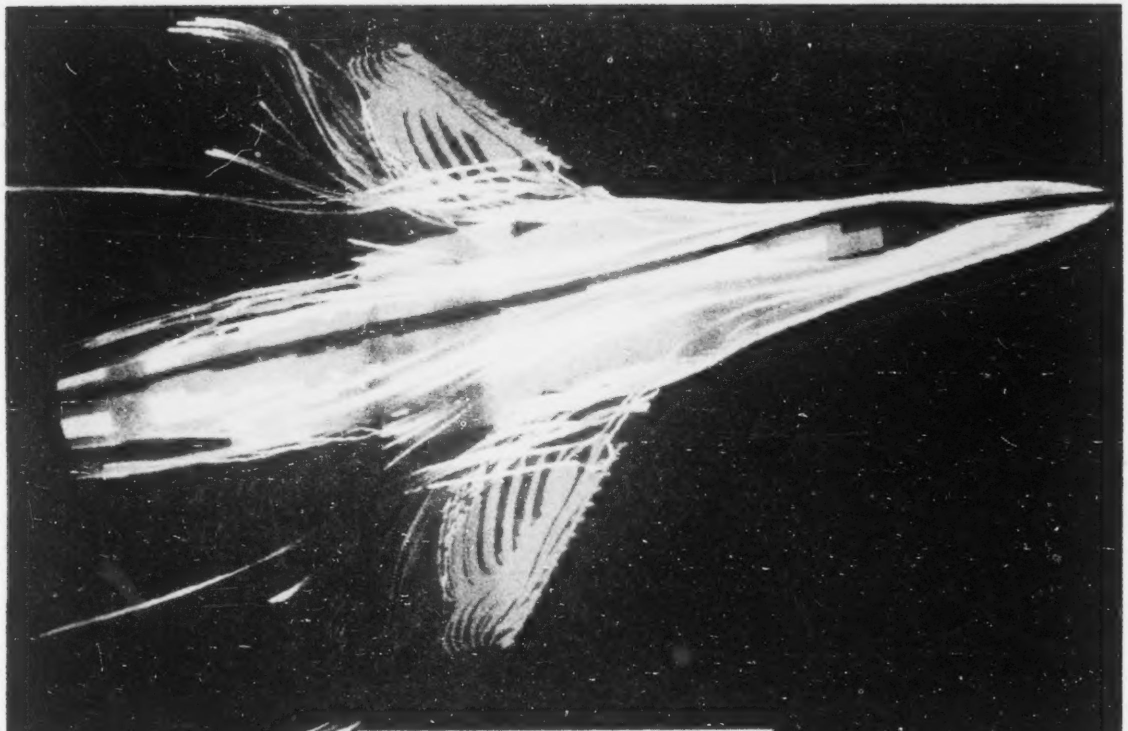


Figure 2. F-16 Calculated Aircraft Flow Field

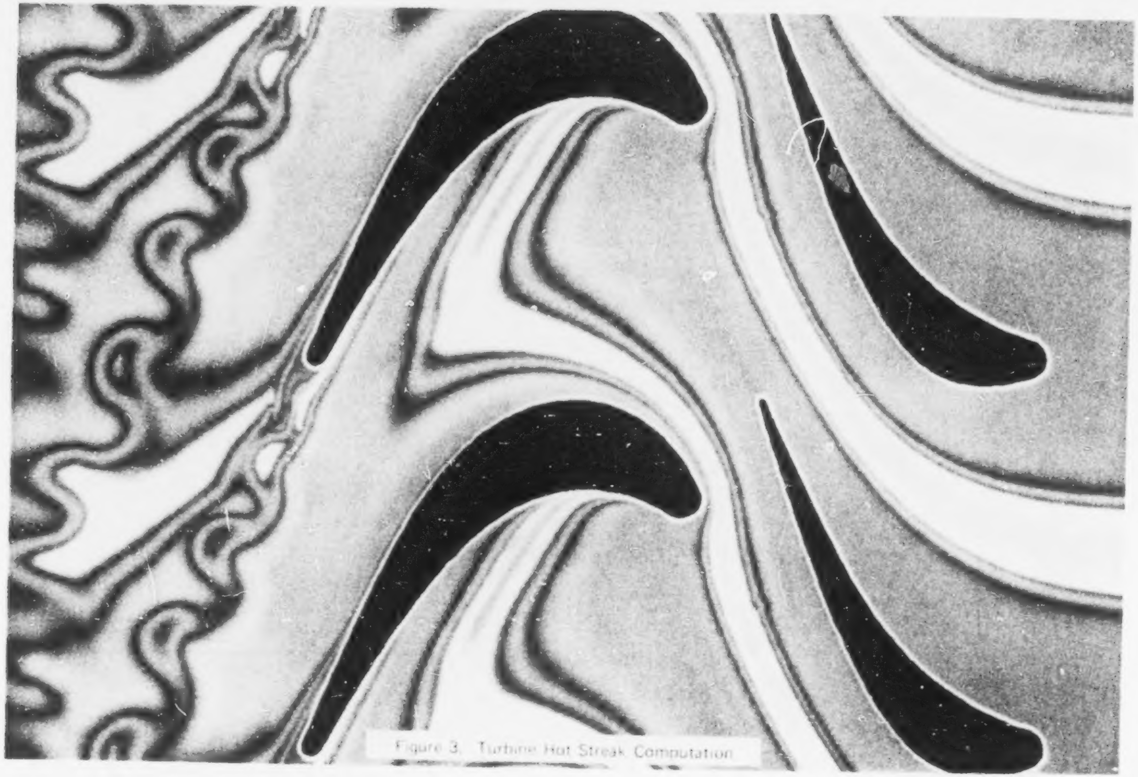


Figure 3. Turbine Hot Streak Computation

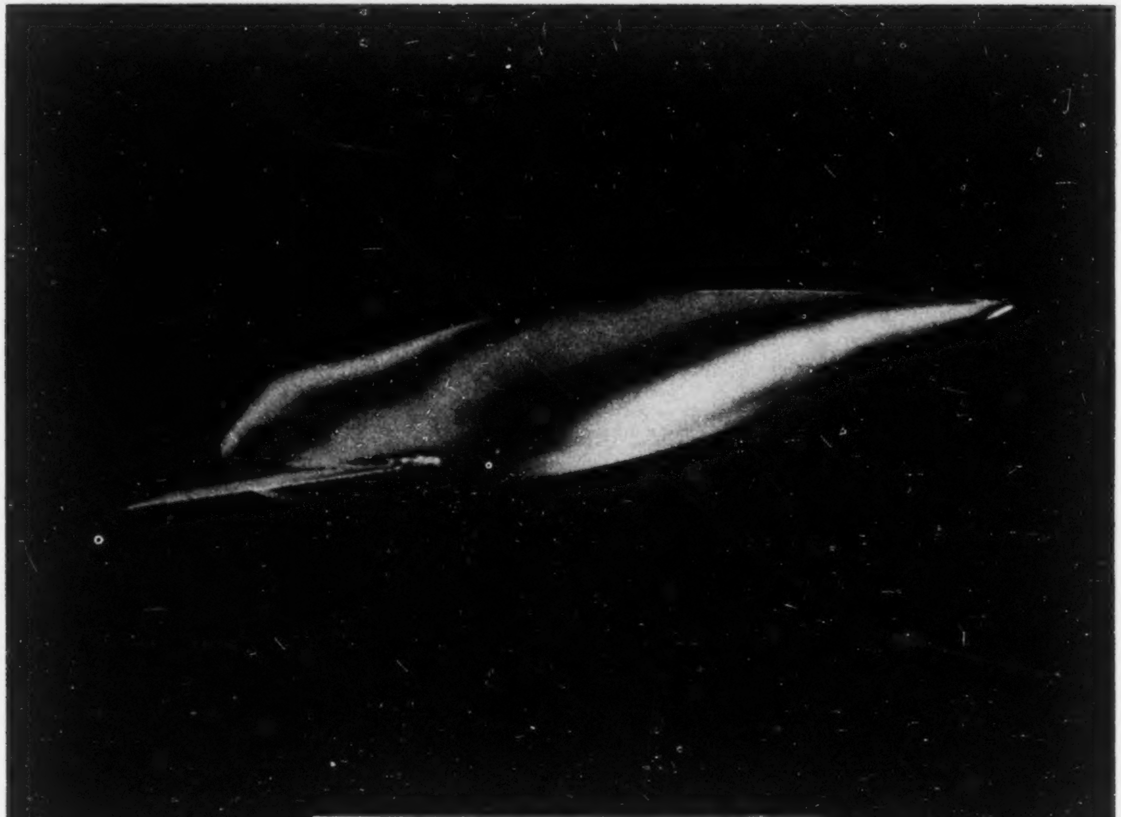
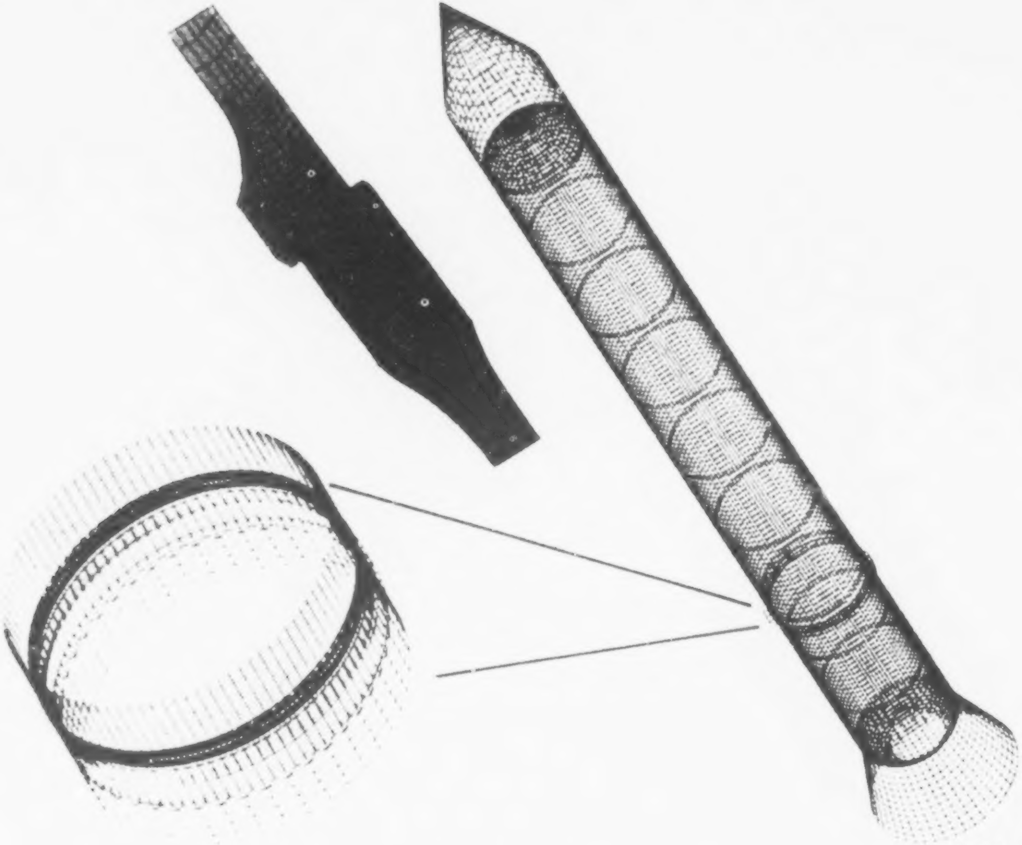


Figure 4. Hypersonic Wing/Body Aerodynamic Computation



HQ R86 804(3)

Figure 5. Solid Rocket Booster Structural Analysis

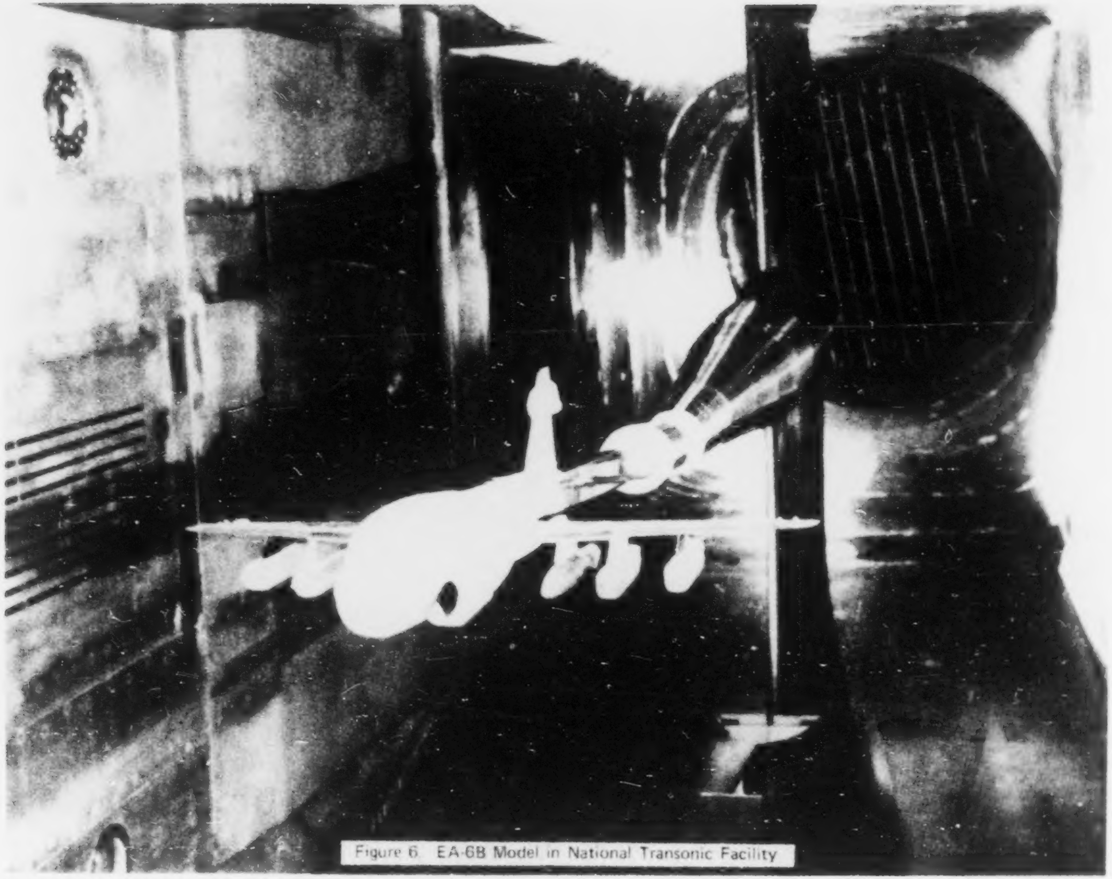


Figure 6. EA-6B Model in National Transonic Facility

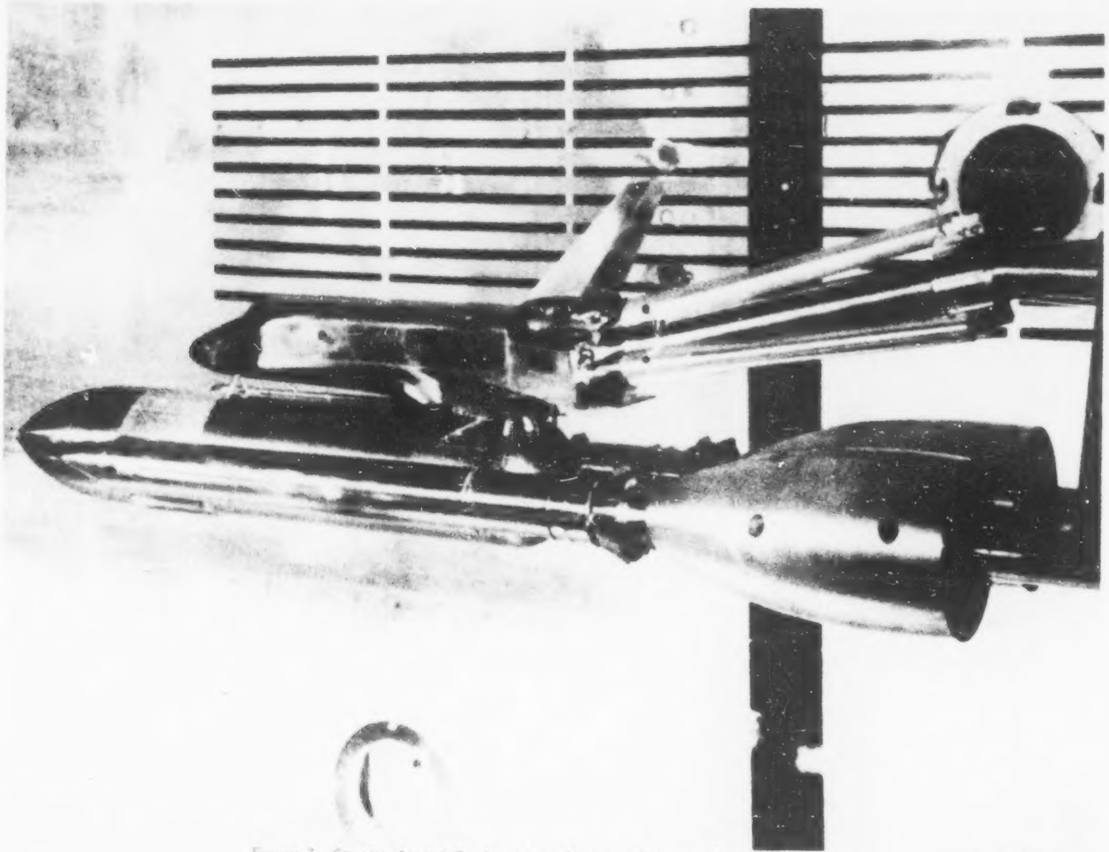


Figure 7. Shuttle Ascent Configuration Model at National Transonic Facility

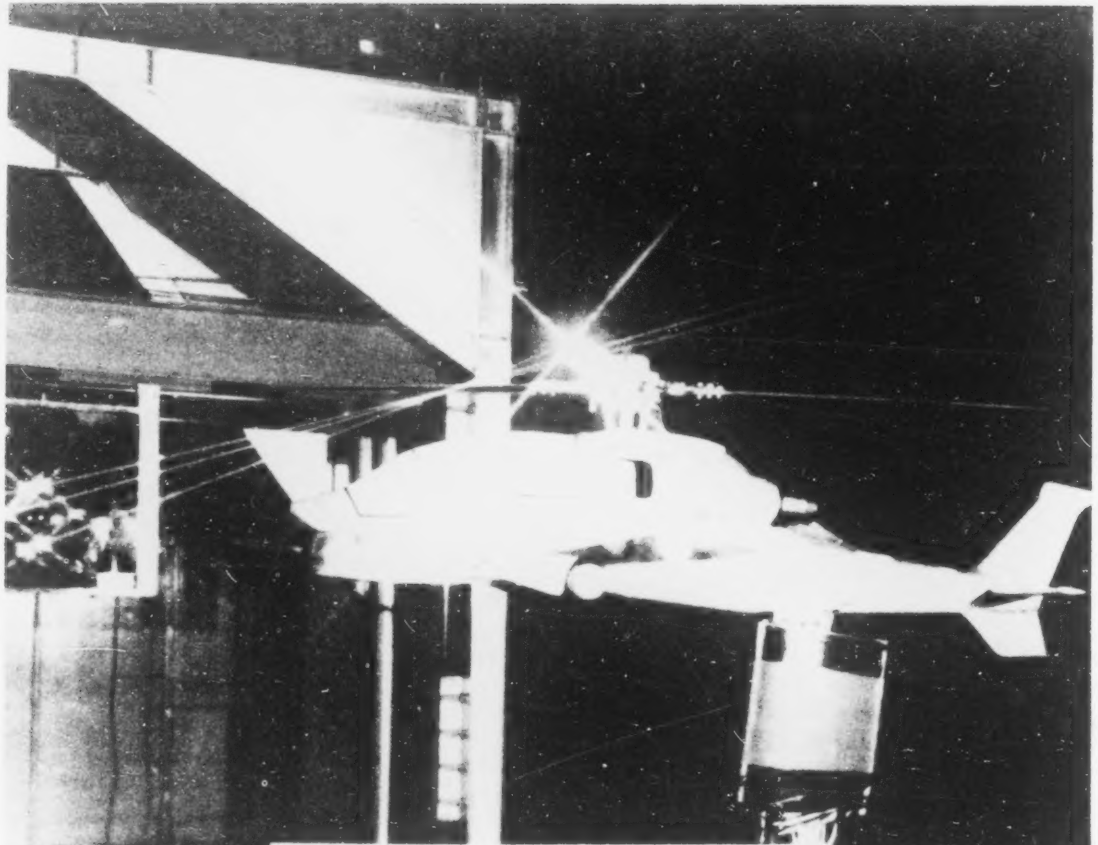


Figure 8. Rotor Flow Field Measurements with Laser-Velocimeter

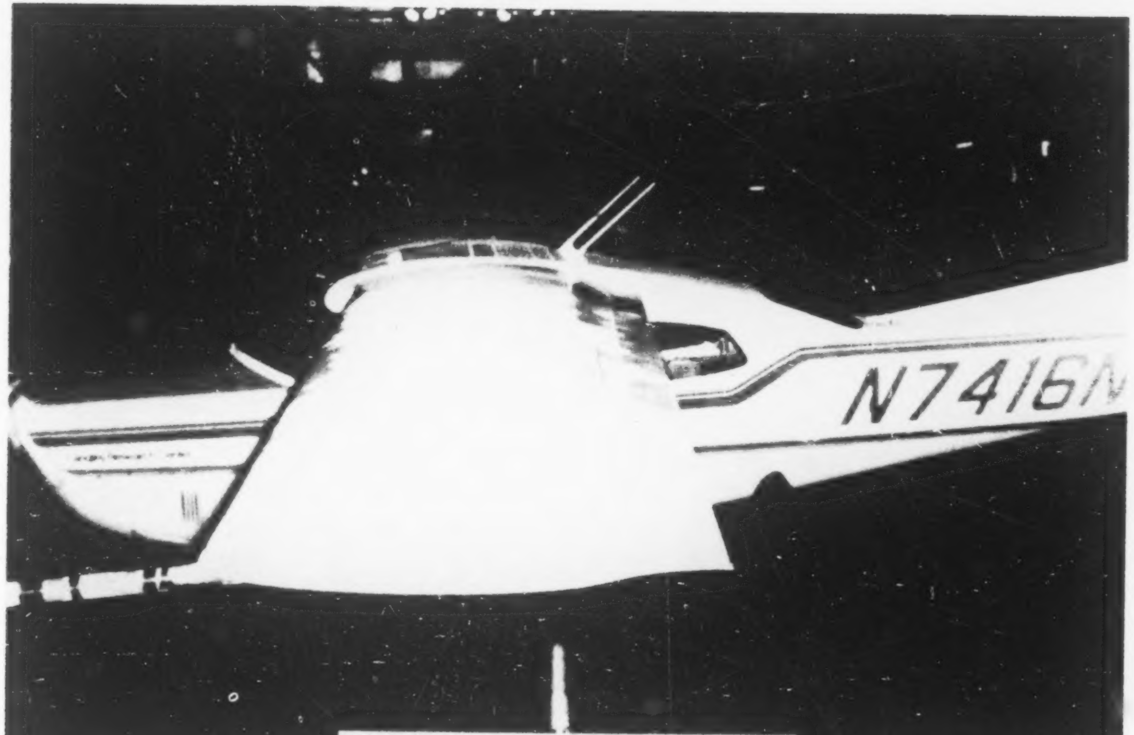


Figure 9. Natural Laminar Flow Wing on Cessna 210

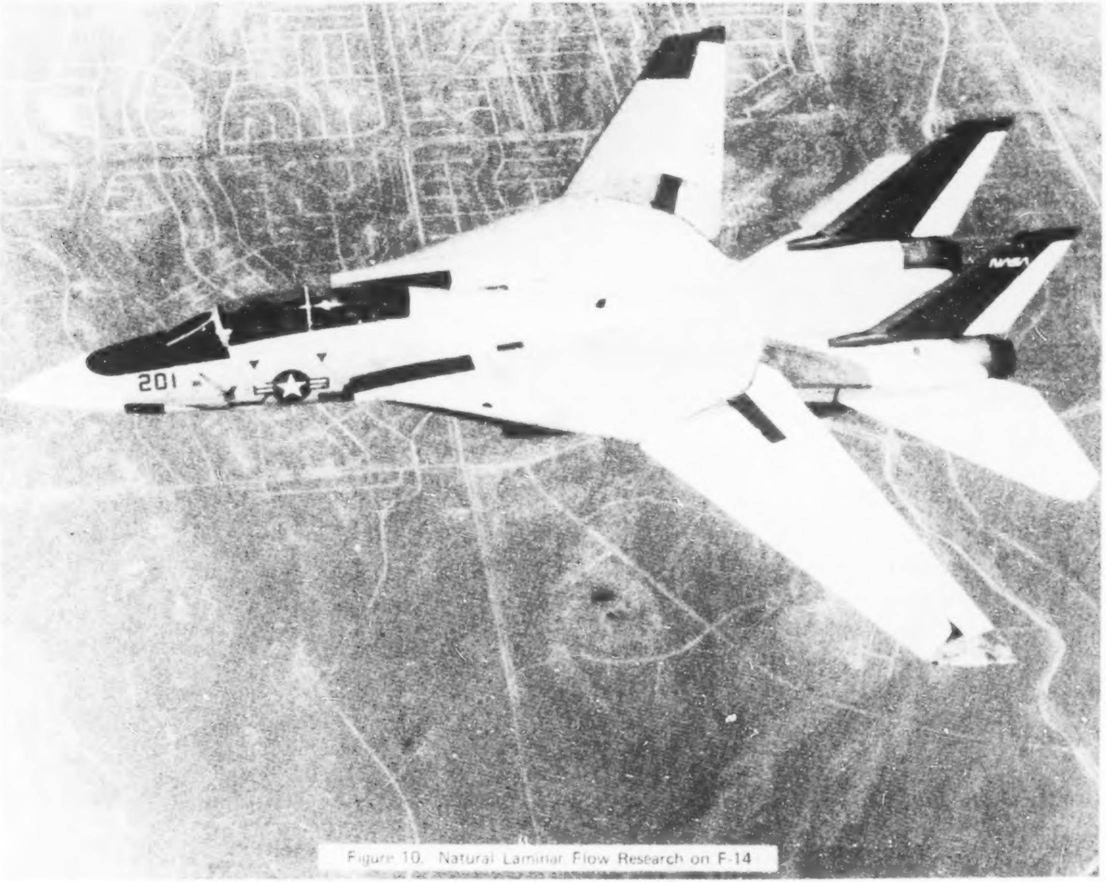


Figure 10. Natural Laminar Flow Research on F-14

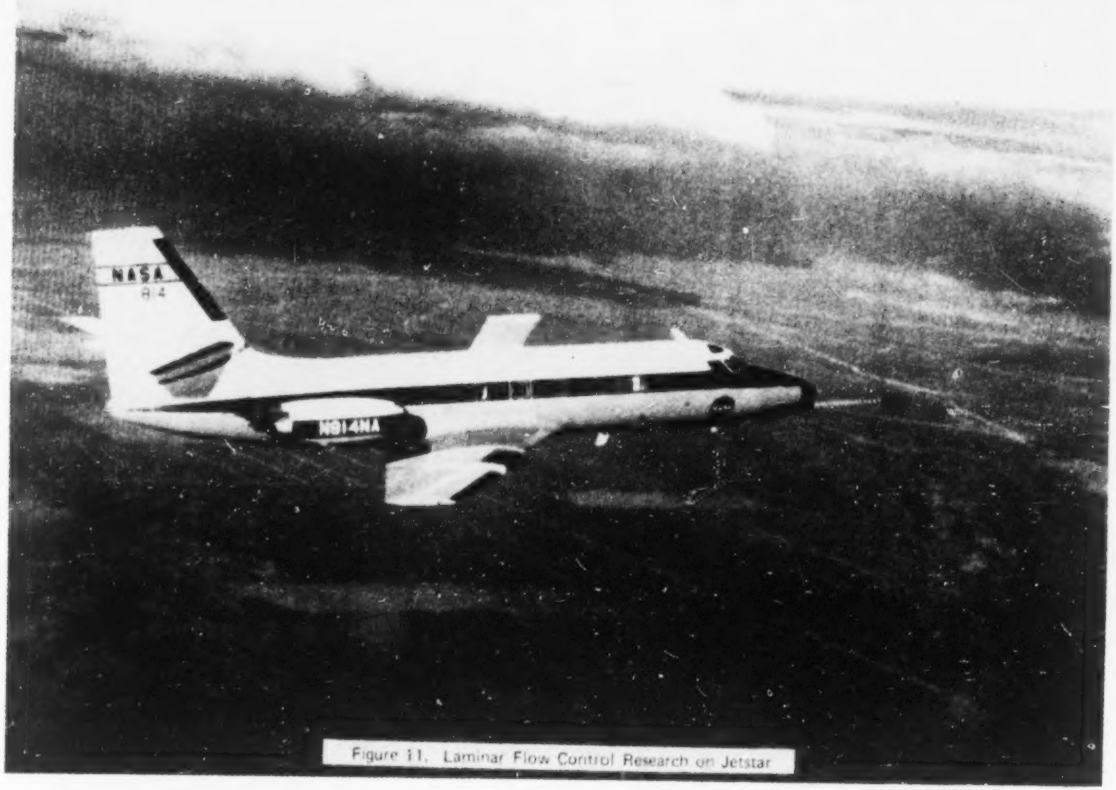

NASA
814
N814NA

Figure 11. Laminar Flow Control Research on Jetstar

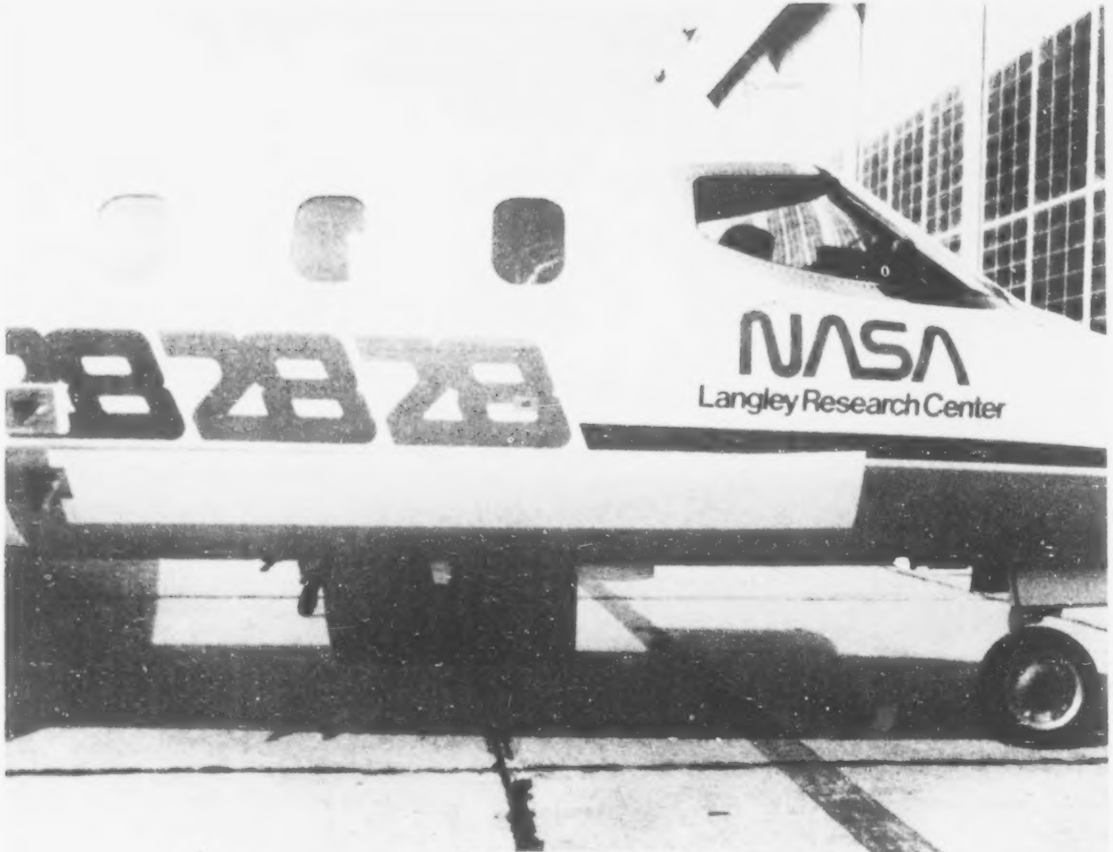

NASA
Langley Research Center

Figure 12. Riblet Test on Learjet Fuselage

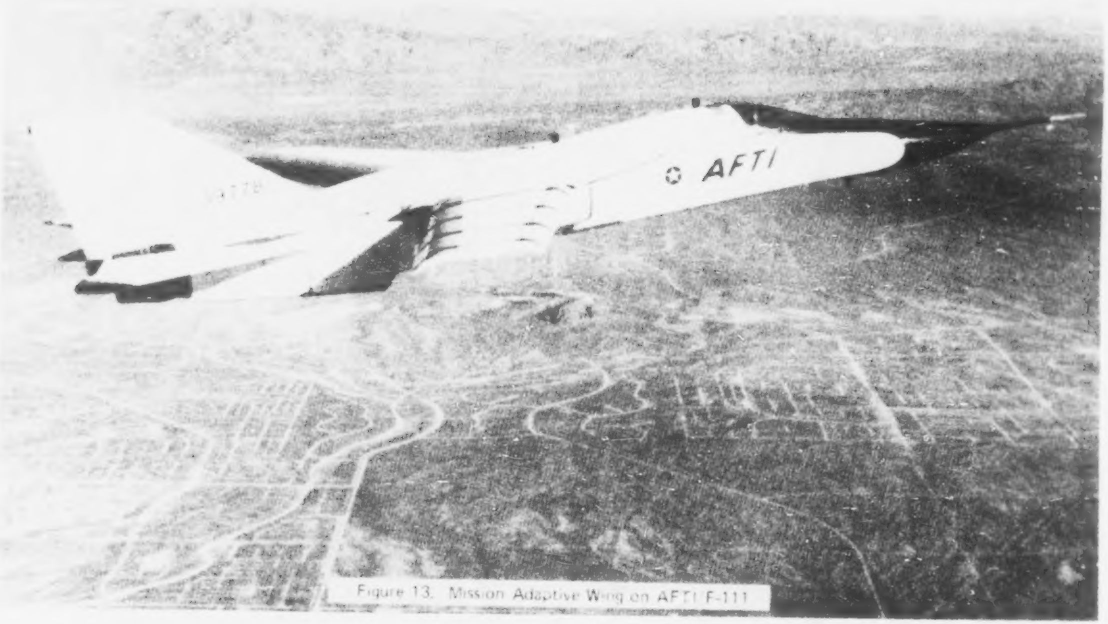


Figure 13. Mission Adaptive Wing on AFTI F-111

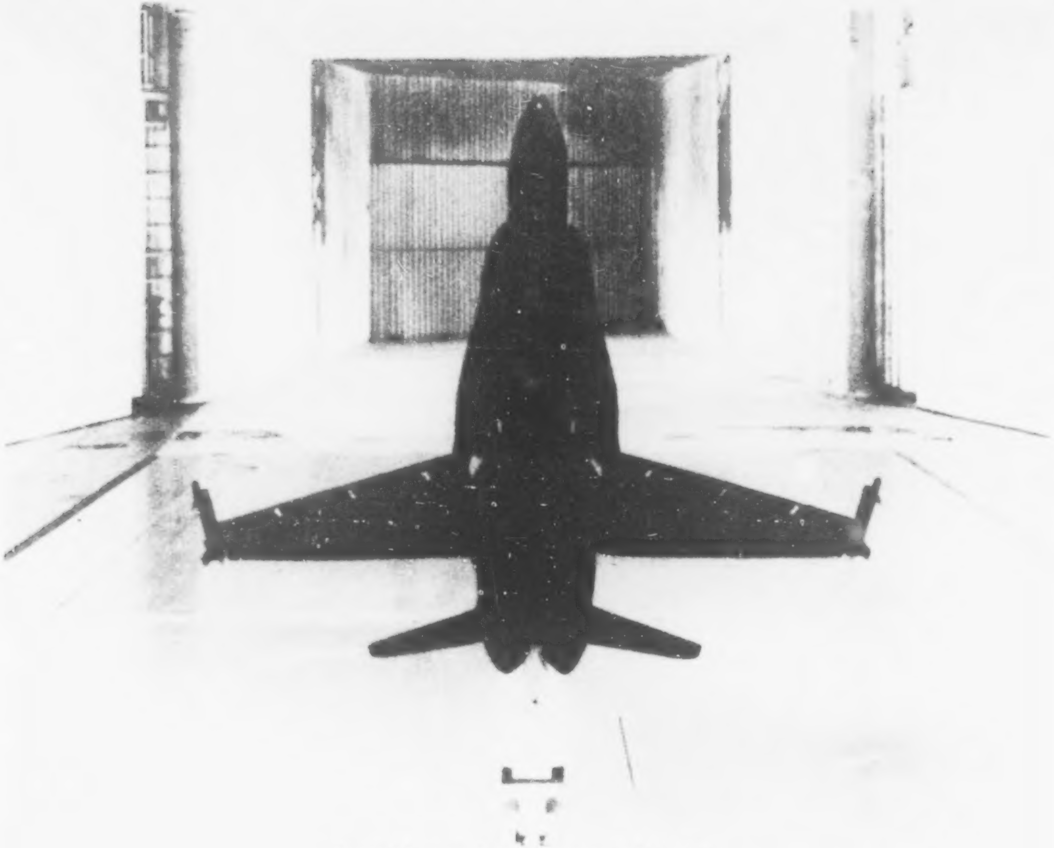


Figure 14. Wind Tunnel Research on F-18 Model

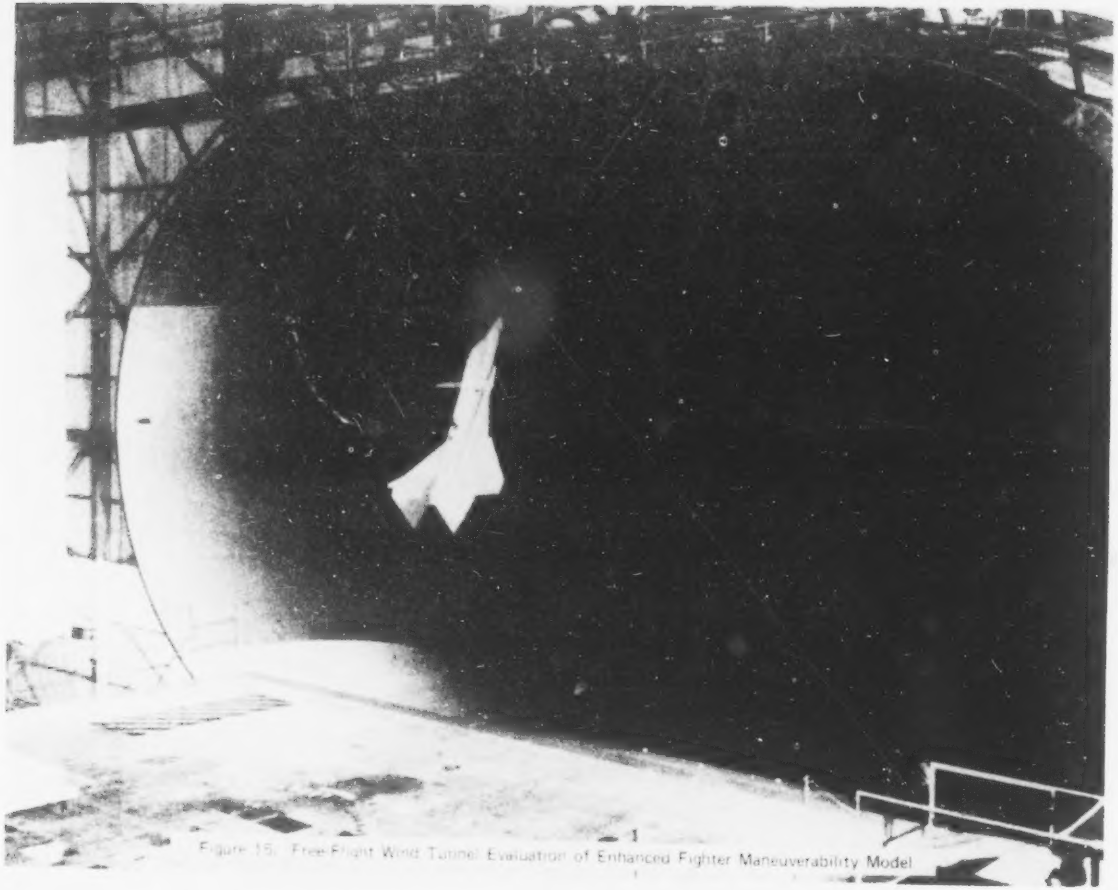


Figure 15. Free-Flight Wind Tunnel Evaluation of Enhanced Fighter Maneuverability Model

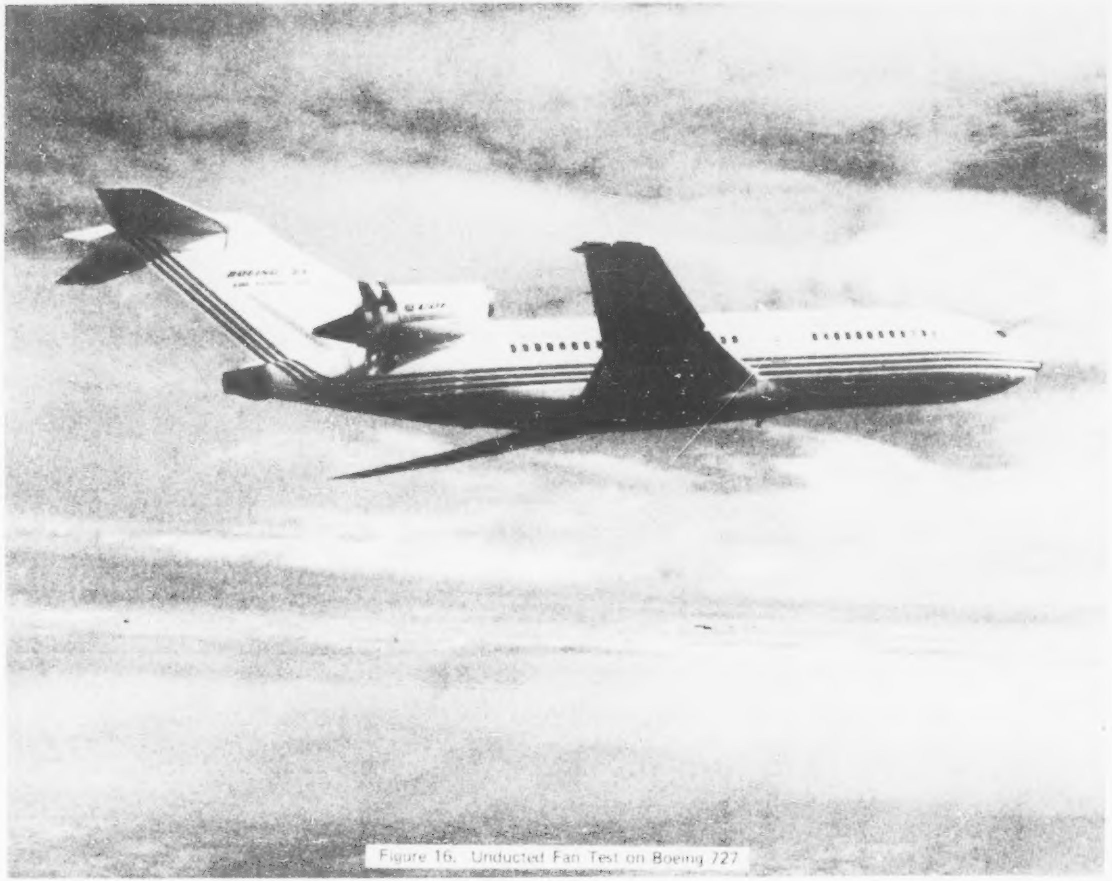


Figure 16. Unducted Fan Test on Boeing 727

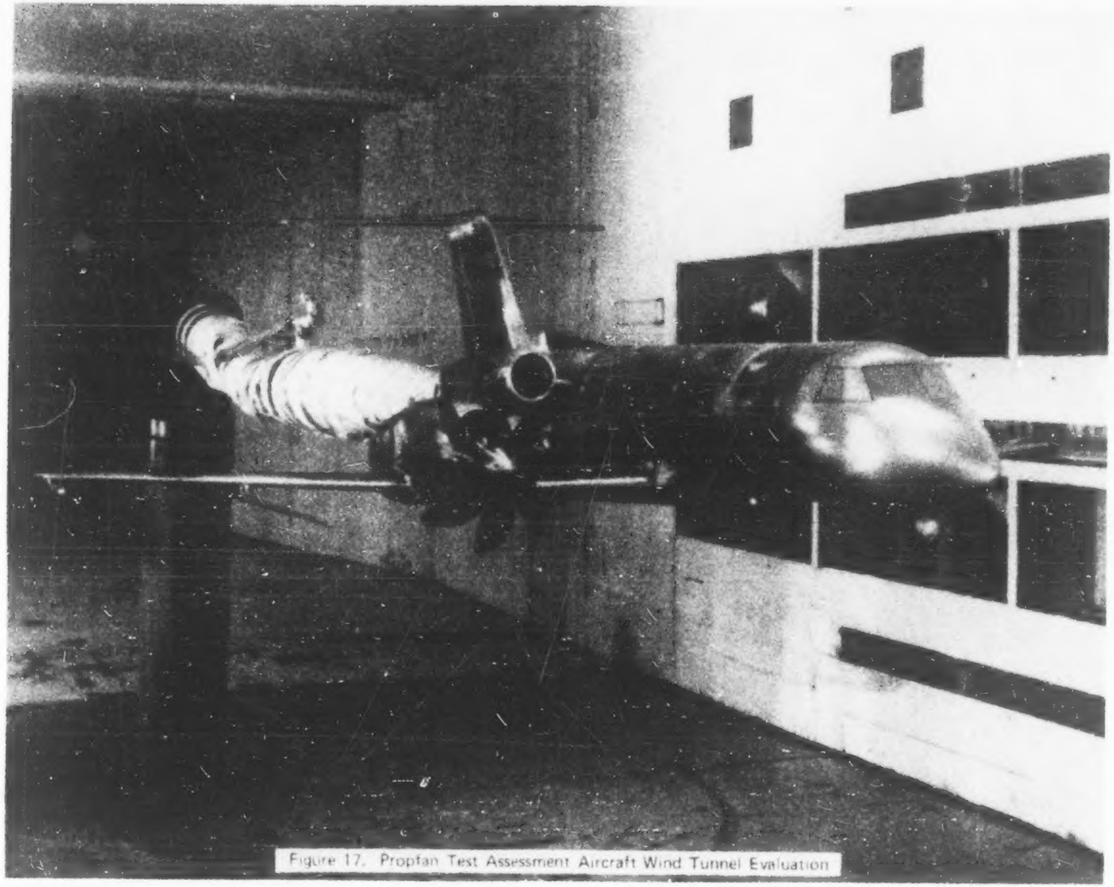


Figure 17. Propfan Test Assessment Aircraft Wind Tunnel Evaluation

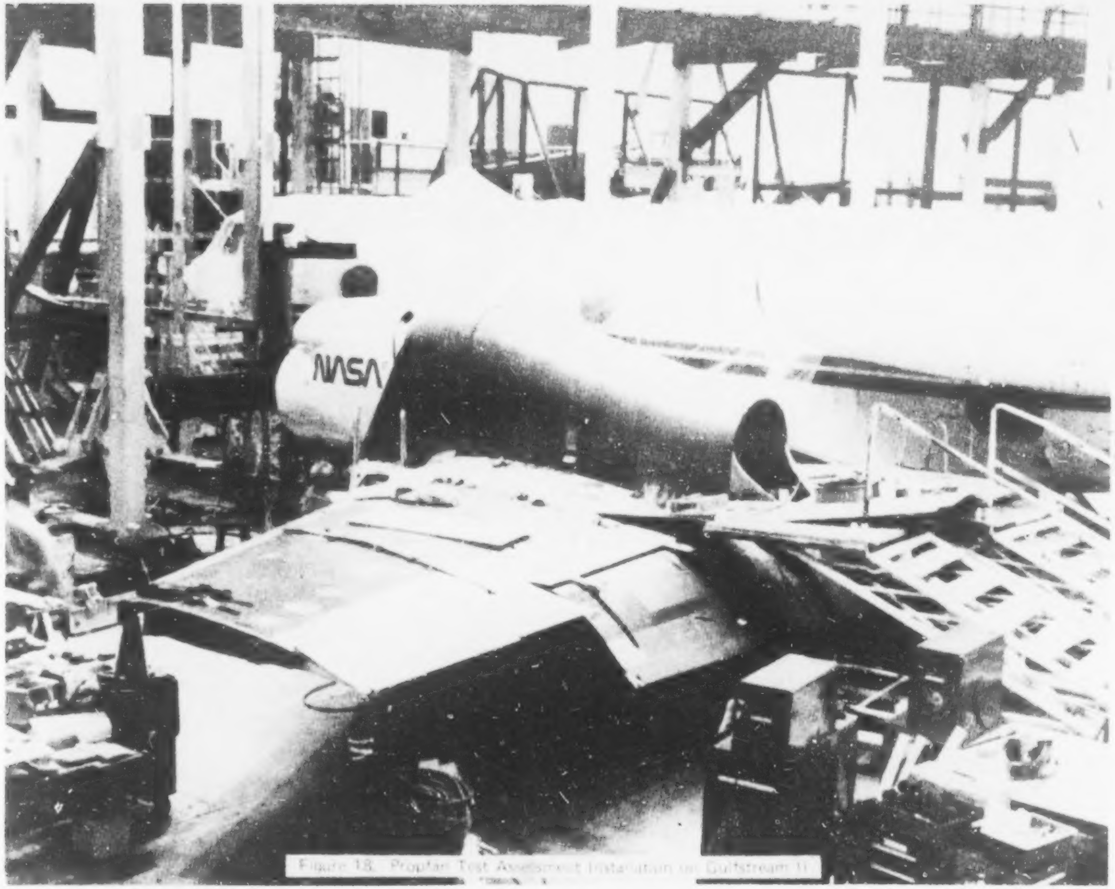


Figure 18. Proptan Test Assessment Installation on Gulfstream II

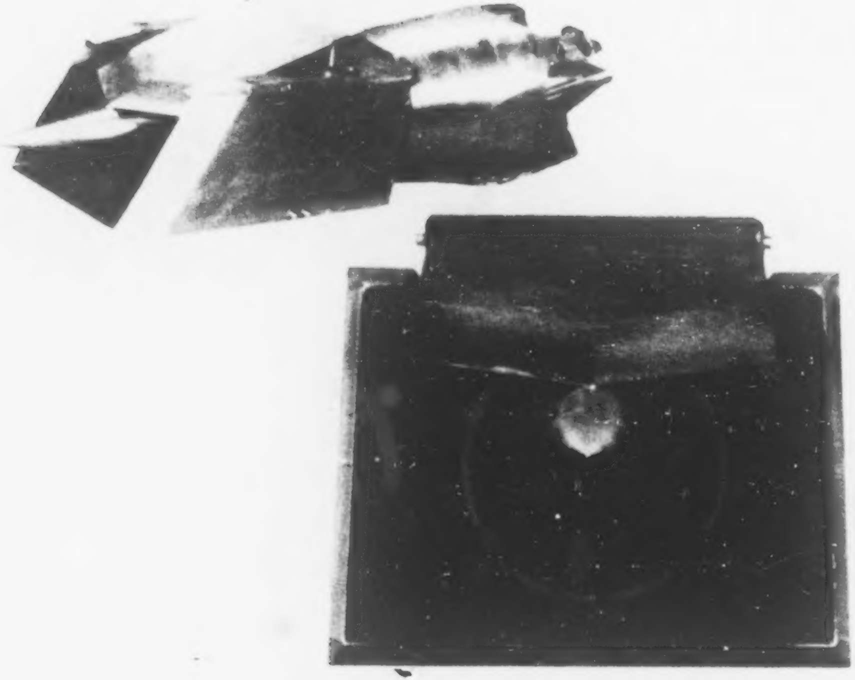


Figure 19. Variable Geometry Inlet Model

F-15 HIDEC
NASA
835

Figure 20. Highly Integrated Digital Electronic Controls (HIDEC) Flight Evaluation on F-15 Aircraft

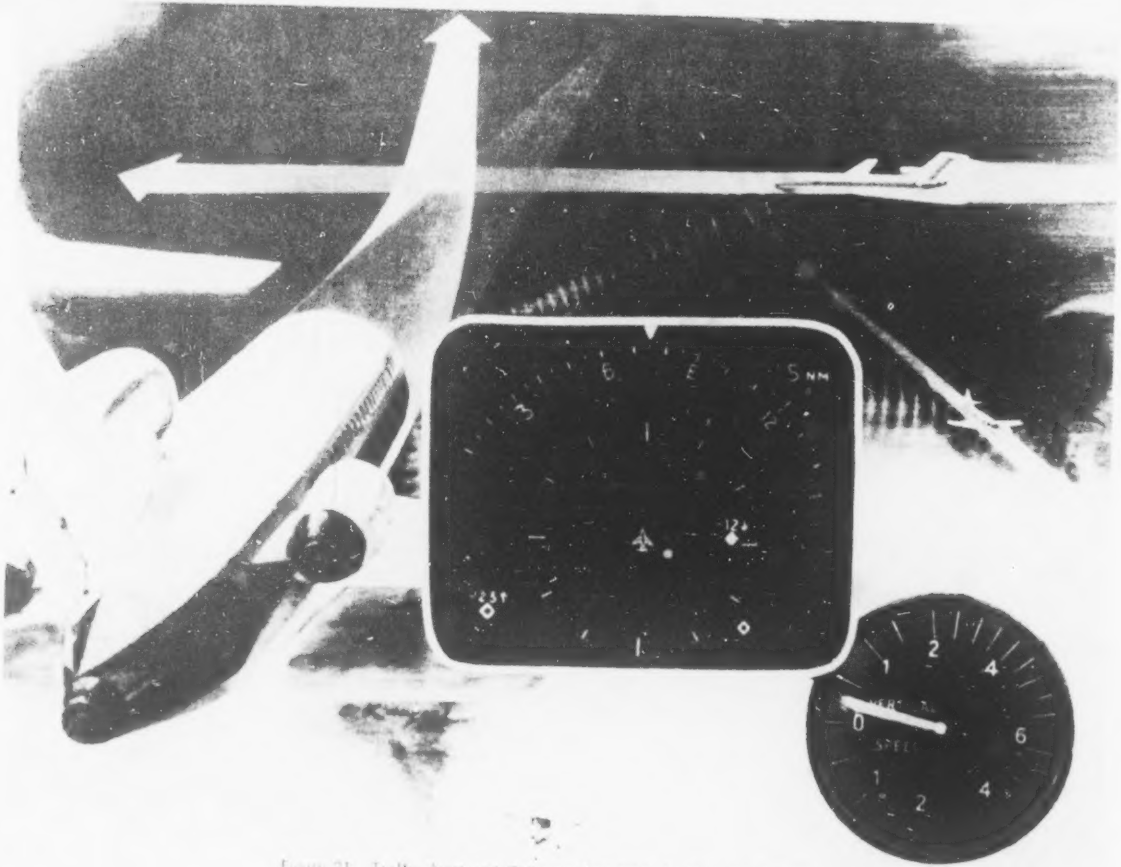

5 NM
12↓
25↑
1
2
4
6
0
4
2
1

Figure 21. Traffic Alert and Collision Avoidance System Illustration

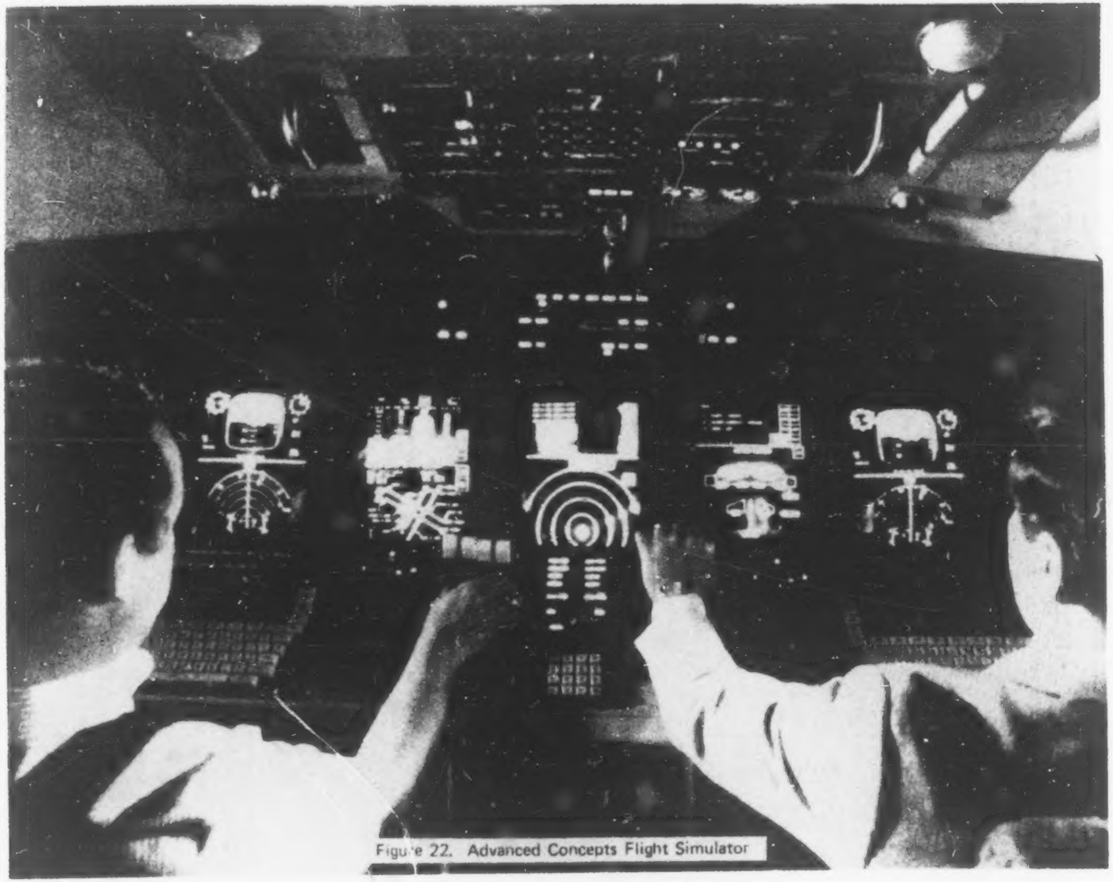


Figure 22. Advanced Concepts Flight Simulator

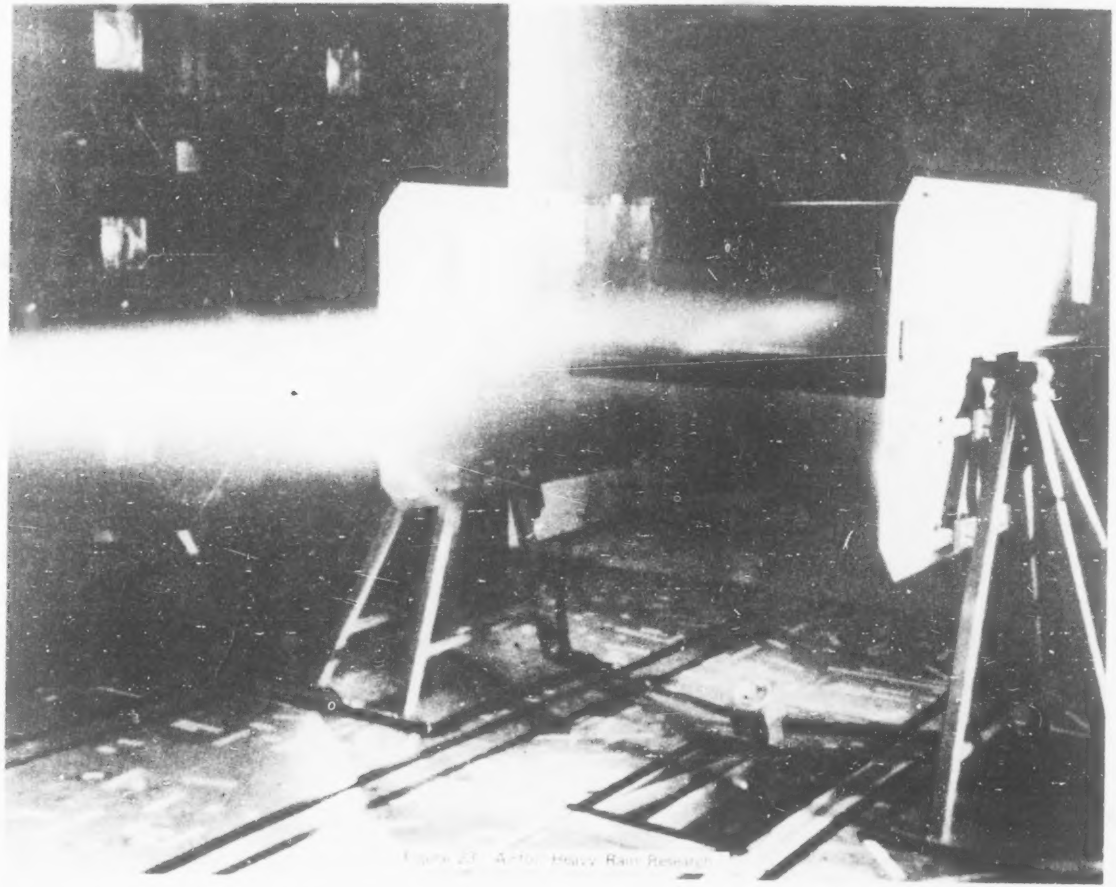


Figure 23. Airfoil Heavy Rain Research

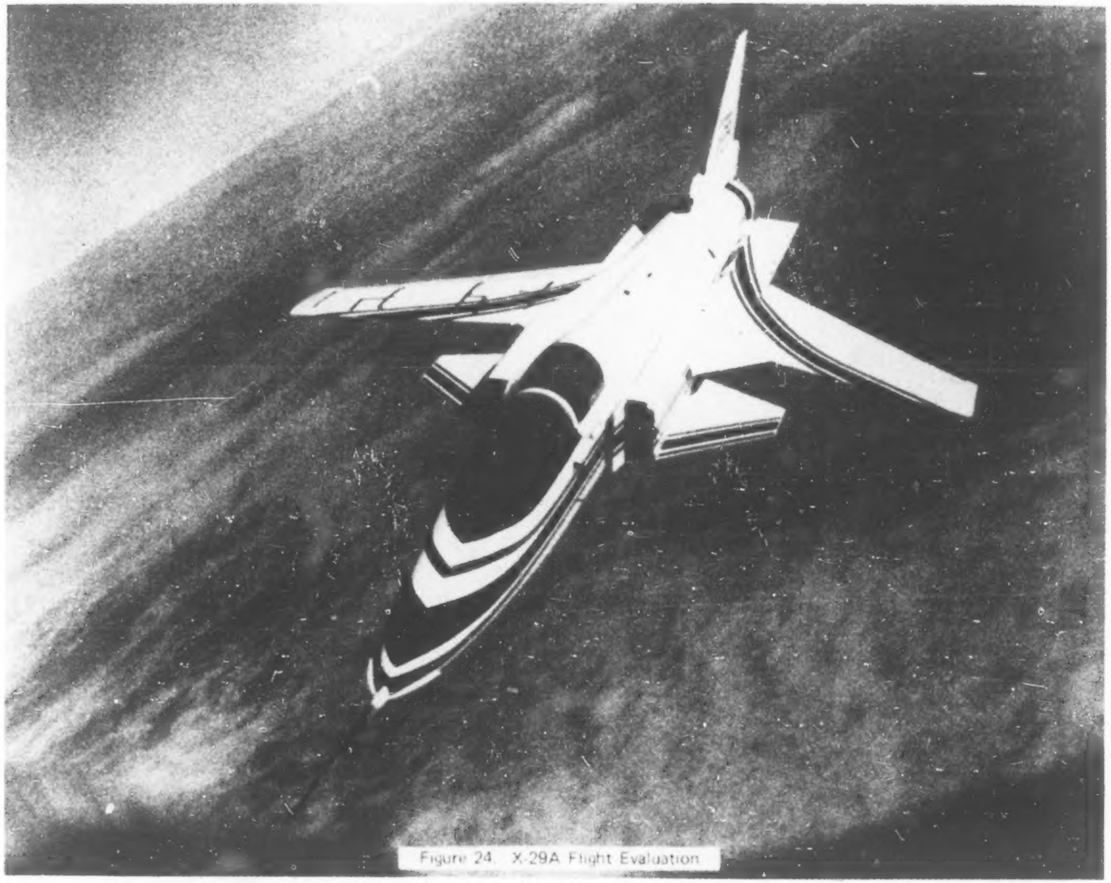


Figure 24. X-29A Flight Evaluation

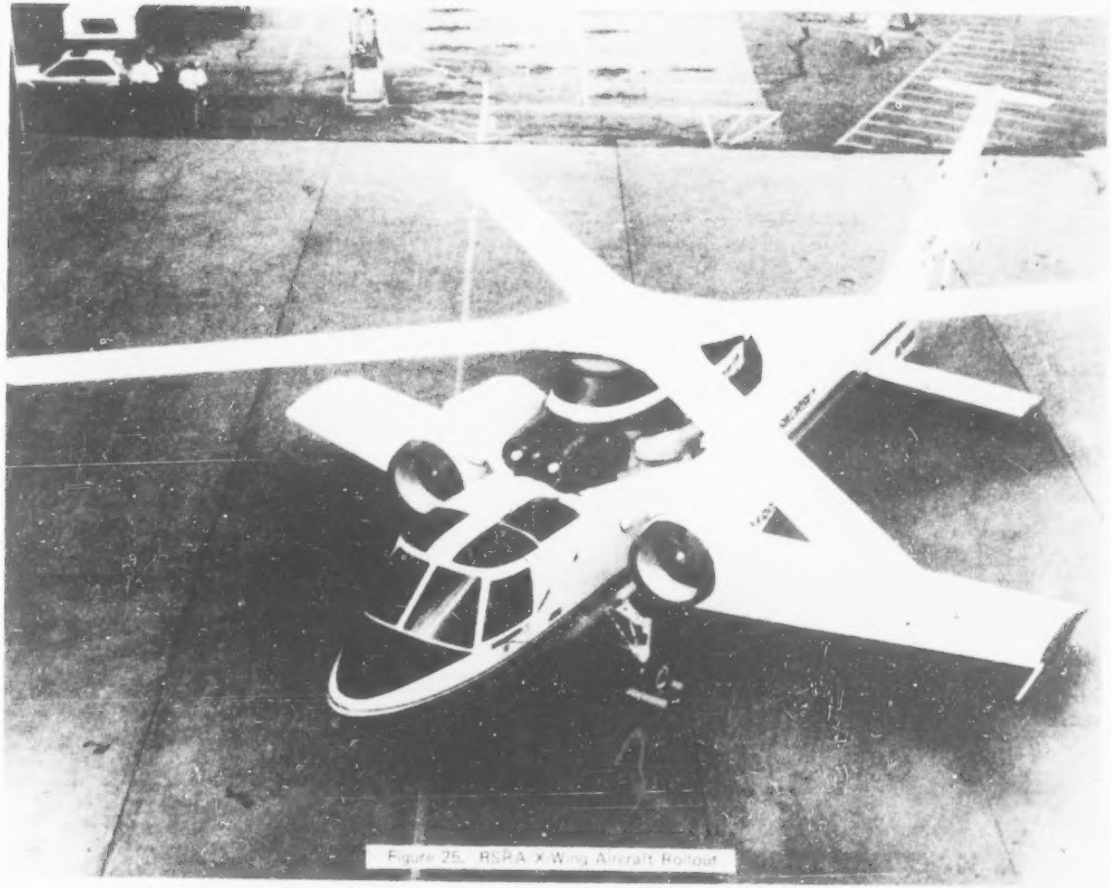


Figure 25. RSRA X-Wing Aircraft Rollout

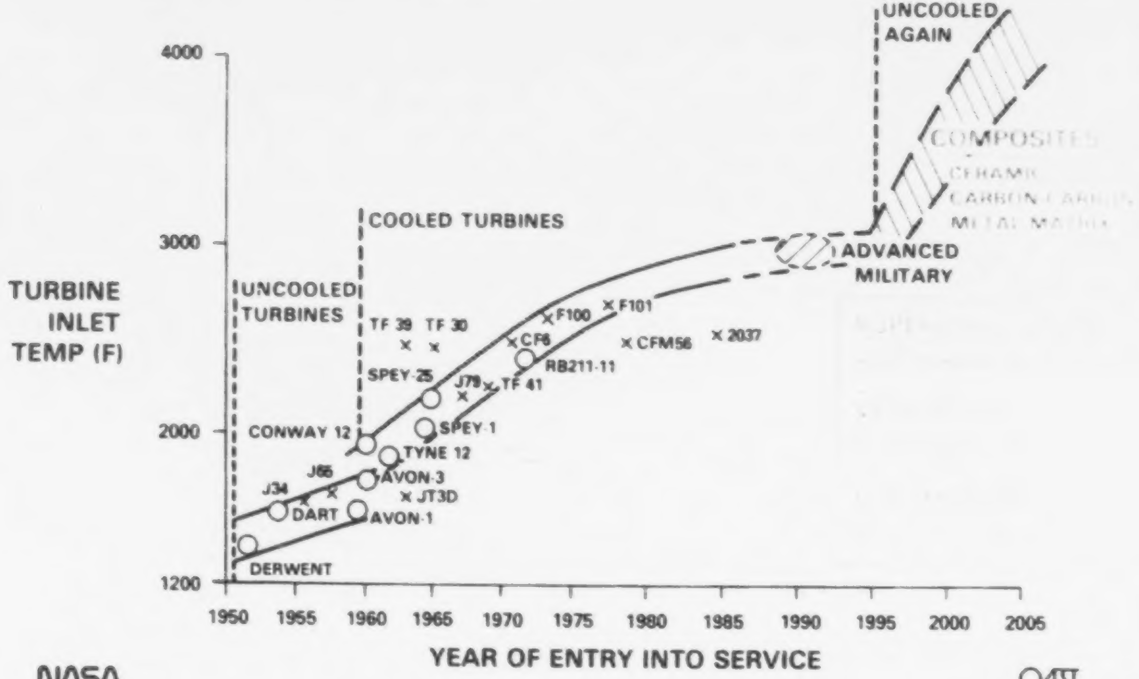
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

R&D BUDGET
($,M)

	FY 1986	FY 1987		FY 1988
	ACTUAL	AMENDED BUDGET	CURRENT ESTIMATE	BUDGET ESTIMATE
AERONAUTICS RESEARCH & TECH.	337.3	376.0	376.0	375.0
SPACE RESEARCH & TECH.	151.4	171.0	171.0	250.0
(CIVIL SPACE TECHNOLOGY INITIATIVE)	(–)	(–)	(–)	(134.1)
TRANSATMOSPHERIC RESEARCH & TECH.	–	35.0	45.0	66.0
(NATIONAL AERO–SPACE PLANE PROGRAM)				

Figure 26. FY 1988 Budget

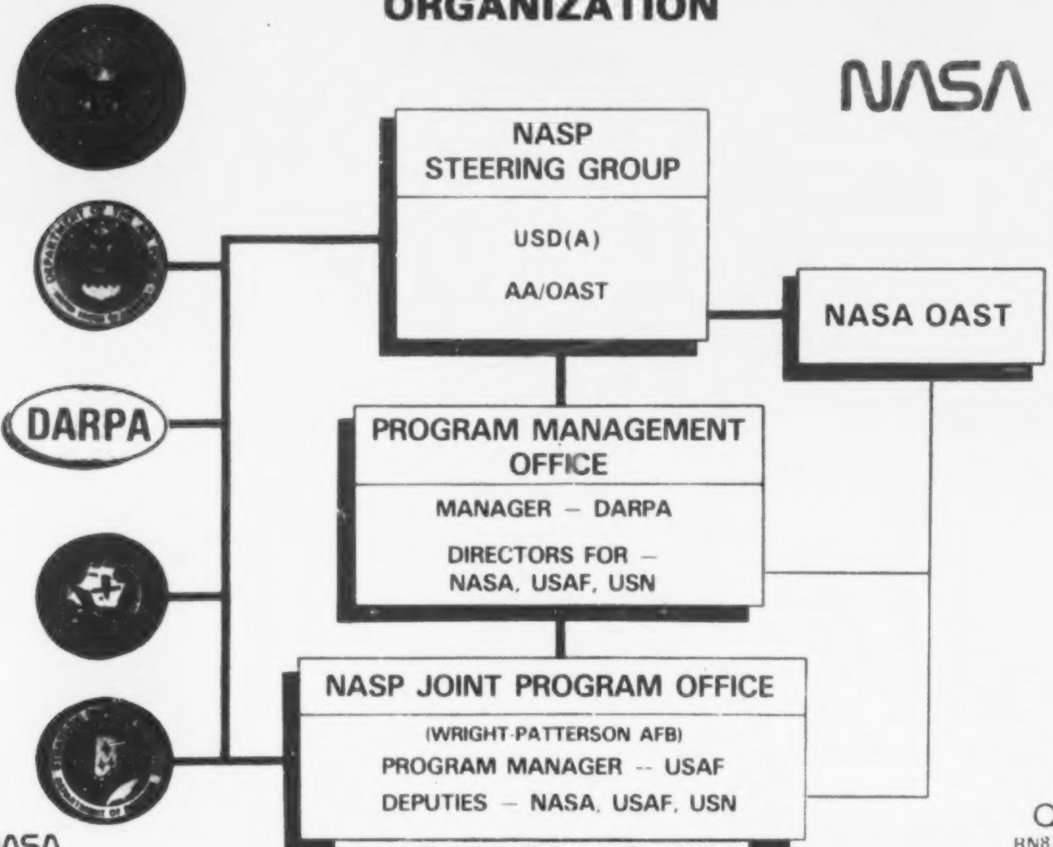
HIGH TEMPERATURE MATERIAL ADVANCES



RJ86 816 (3)

Figure 27. High-Temperature Engine Materials

NATIONAL AERO-SPACE PLANE PROGRAM ORGANIZATION



NASA

NASP STEERING GROUP

USD(A)

AA/OAST

NASA OAST

DARPA

PROGRAM MANAGEMENT OFFICE

MANAGER – DARPA

DIRECTORS FOR – NASA, USAF, USN

NASP JOINT PROGRAM OFFICE

(WRIGHT-PATTERSON AFB)

PROGRAM MANAGER -- USAF

DEPUTIES – NASA, USAF, USN

NASA

OAST
RN87 185(3)

Figure 28. The NASP Program Organization

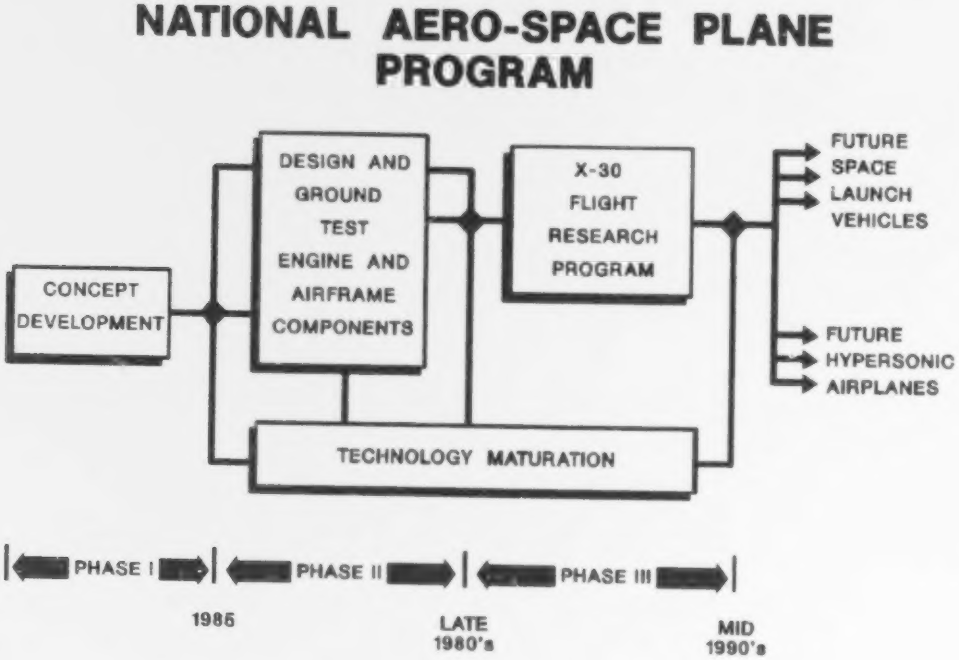

NATIONAL AERO-SPACE PLANE PROGRAM
CONCEPT DEVELOPMENT
DESIGN AND GROUND TEST ENGINE AND AIRFRAME COMPONENTS
X-30 FLIGHT RESEARCH PROGRAM
FUTURE SPACE LAUNCH VEHICLES
FUTURE HYPERSONIC AIRPLANES
TECHNOLOGY MATURATION
PHASE I
PHASE II
PHASE III
1985
LATE 1980's
MID 1990's

Figure 29. The NASP Program Phases

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

R&D BUDGET
($,M)

	FY 1986	FY 1987	FY 1988
NATIONAL AERO-SPACE PLANE PROGRAM	61.0	172.0	325.0
NASA	16.0	62.0	84.0
TRANSATMOSPHERIC R&T	—	45.0	66.0
AERONAUTICS & SPACE R&T BASE	16.0	17.0	18.0
DOD	45.0	110.0	241.0
DARPA	20.0	100.0	—
AIR FORCE	10.0	—	241.0
NAVY	6.0	—	—
SDIO	9.0	10.0	—

Figure 30. The Joint DOD/NASA NASP Budget

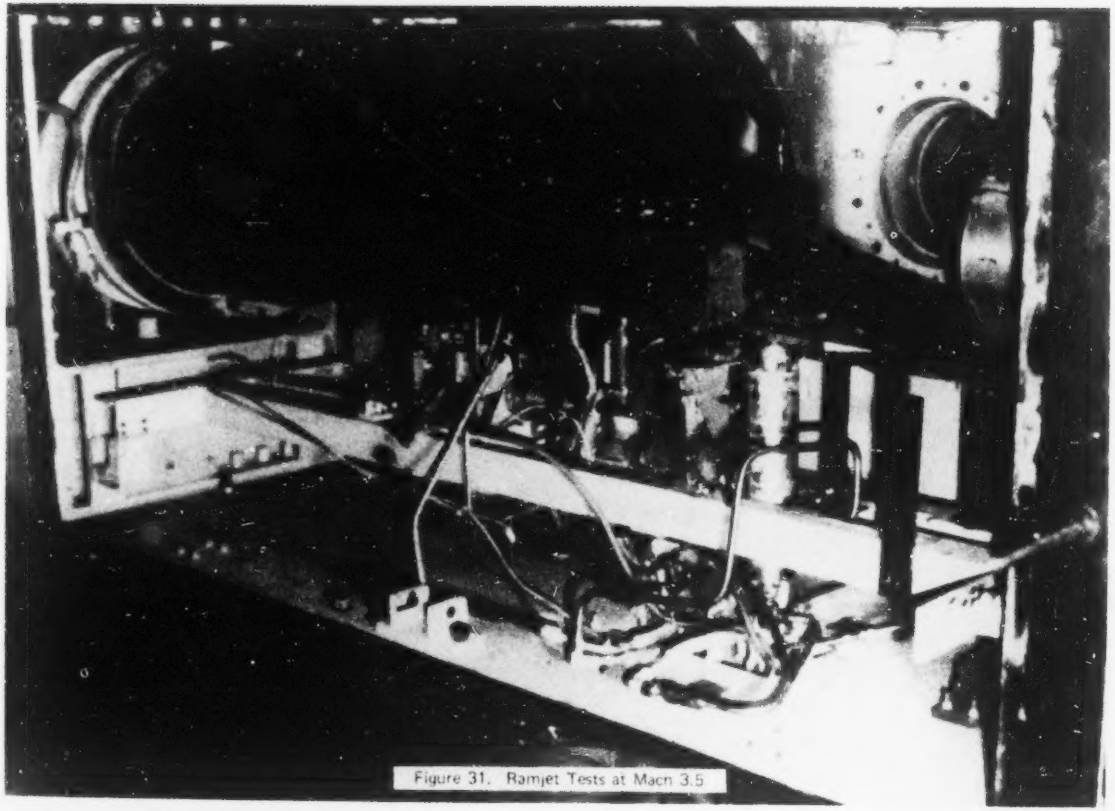


Figure 31. Ramjet Tests at Mach 3.5

[Whereupon at 4:10 p.m. the Subcommittee recessed to reconvene at the call of the Chair.]

1988 NASA AUTHORIZATION

WEDNESDAY, MARCH 11, 1987

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Transportation,
Aviation, and Materials,
Washington, DC.

The subcommittee met, pursuant to notice, at 2 p.m., in Room 2325, Rayburn House Office Building, Hon. Dave McCurdy (chairman of the subcommittee) presiding.

Mr. McCurdy. Gentlemen, we're just commenting here on how we need to forego straightshooters and boots, and put our running shoes on. This schedule is absolutely crazy right now, and we're all being tugged and pulled from every direction, but hopefully we'll have about a couple of hours at least to—that should be uninterrupted because of the debate on the Floor, and we don't expect a vote for some time, so perhaps we can get through this block of hearings.

Today the Subcommittee will conclude its hearings on fiscal year 1988 budget requests for NASA aeronautical programs. We plan to hear from 4 groups, each of whom have looked at the NASA program or selected parts of it.

The first, known as the Congressional Aeronautical Advisory Committee, is established by this Subcommittee for the purpose of reviewing in detail, the aeronautics budget request. Composed of experts from industry, academia and the military, this group spent many dedicated hours since last fall examining virtually all of NASA's research projects and considering a number of larger issues as well.

The second group, representing the National Research Council's Aeronautics and Space Engineering Board, looked at the NASA program from a broad perspective.

Our third group is a Subcommittee of the first, constituted to form a separate detailed look at a special topic, the effectiveness of NASA's own advisory system.

Finally, we will hear from the American Institute of Aeronautics and Astronautics which represents many of the professional engineers and the scientists in this field.

At this point I would recognize the gentleman from Florida, Mr. Lewis.

Mr. Lewis. Thank you, Mr. Chairman.

This afternoon we will have the opportunity to hear from various advisory groups that have examined the NASA Aeronautics budget. I would like each group to know that we in Congress great-

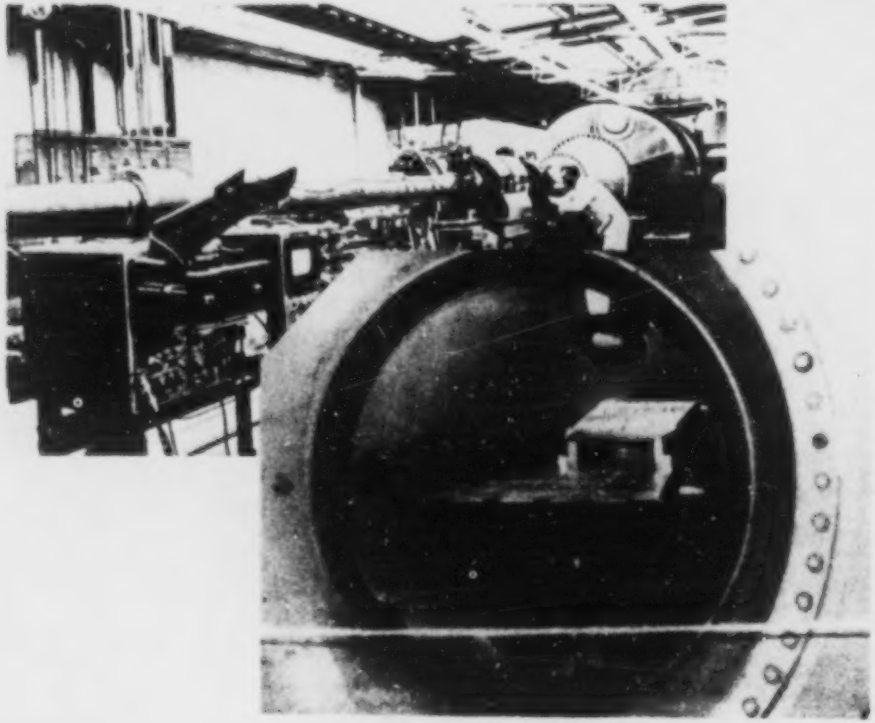


Figure 32. Scramjet Tests at Mach 10

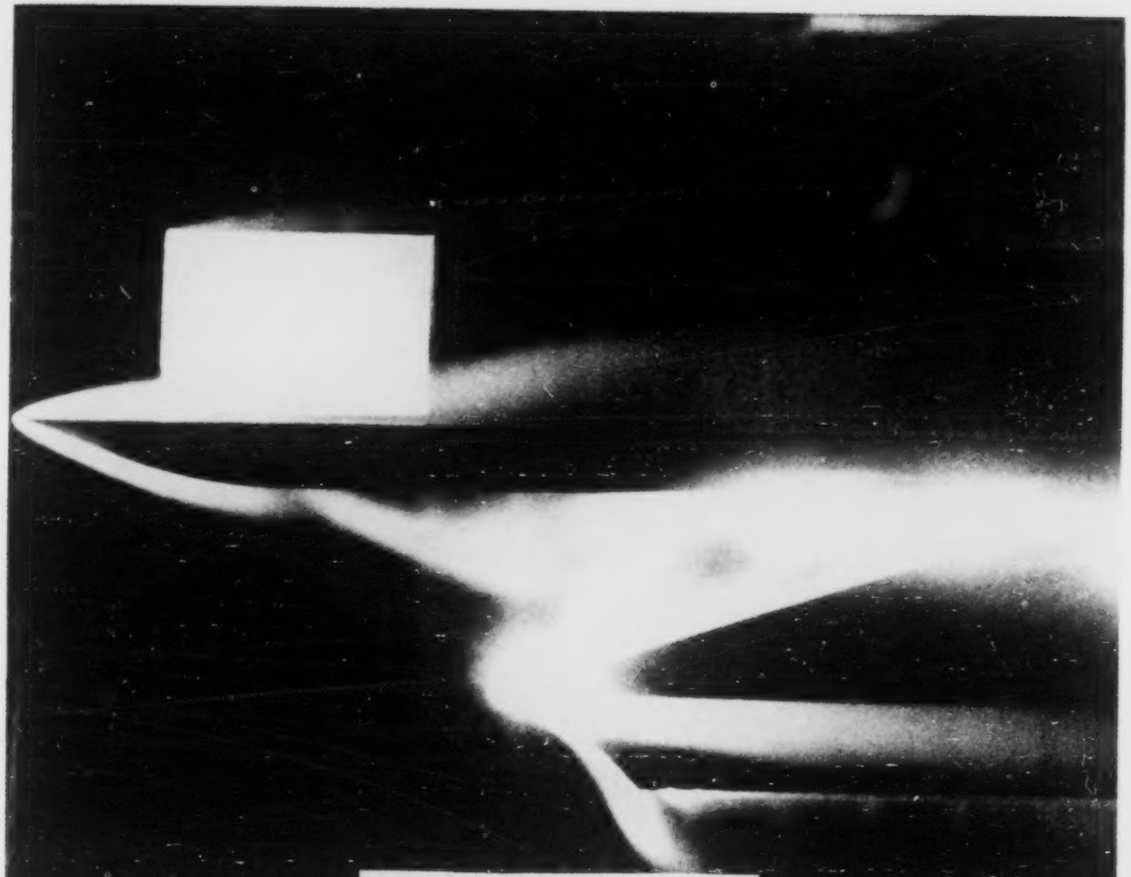


Figure 33. Hypersonic Inlet Tests at Mach 8

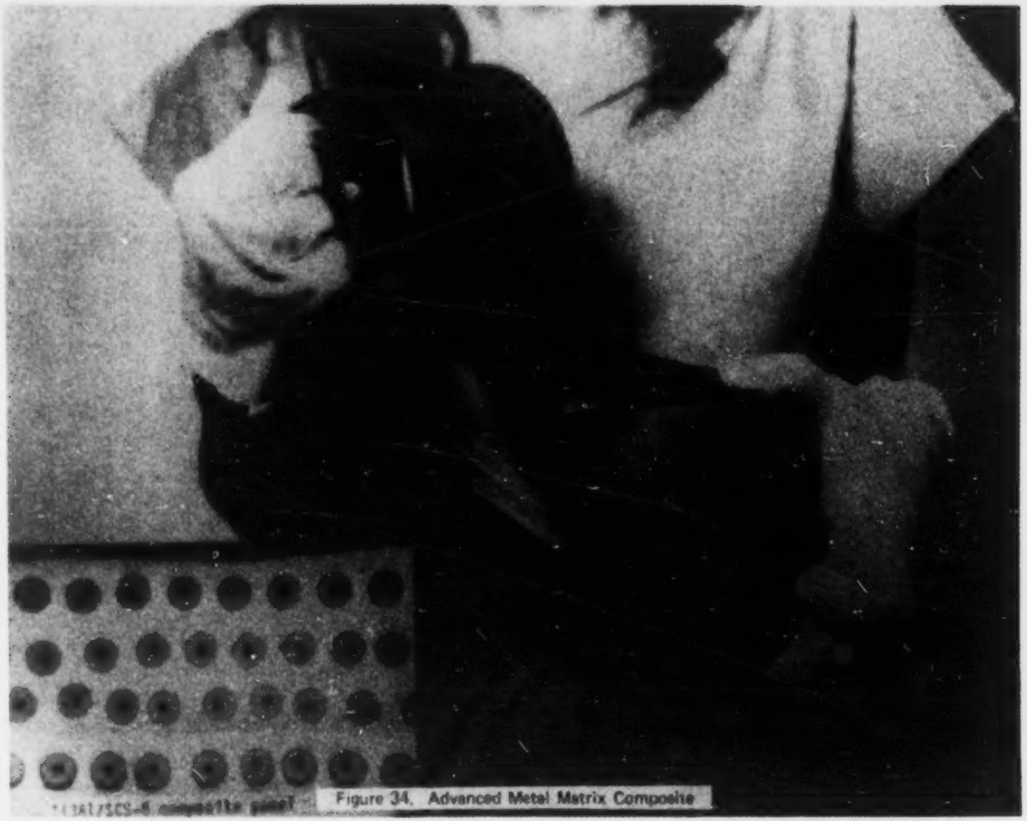

Ti3Al/SCS-6 composite panel

Figure 34. Advanced Metal Matrix Composite

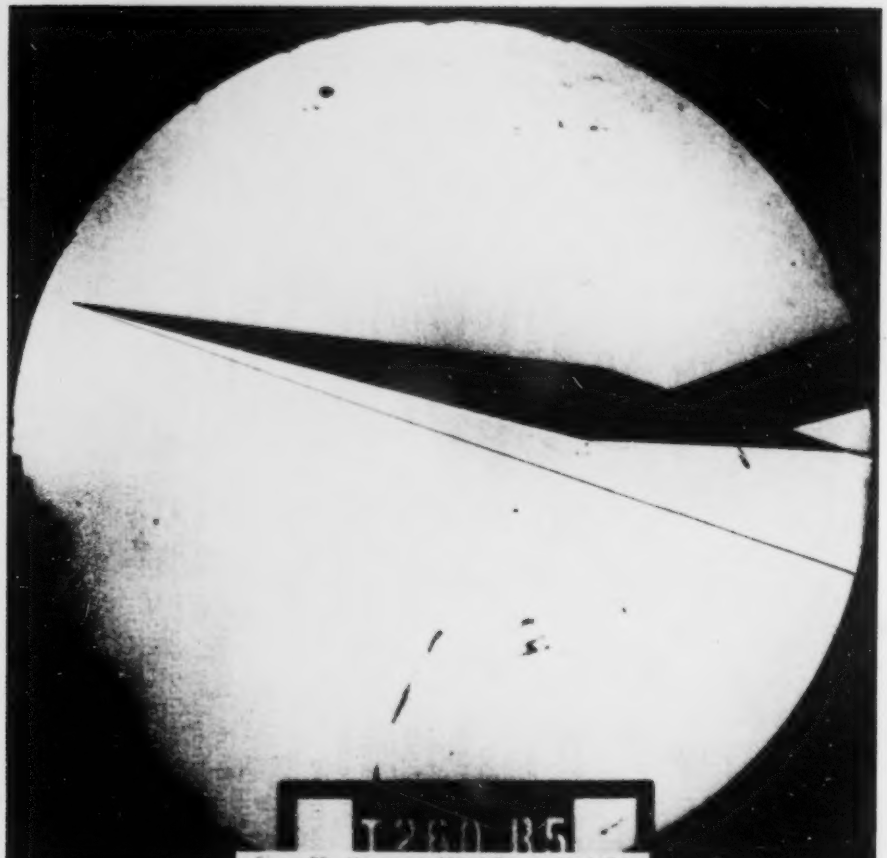


Figure 35. Hypersonic Model Tests at Mach 7.4

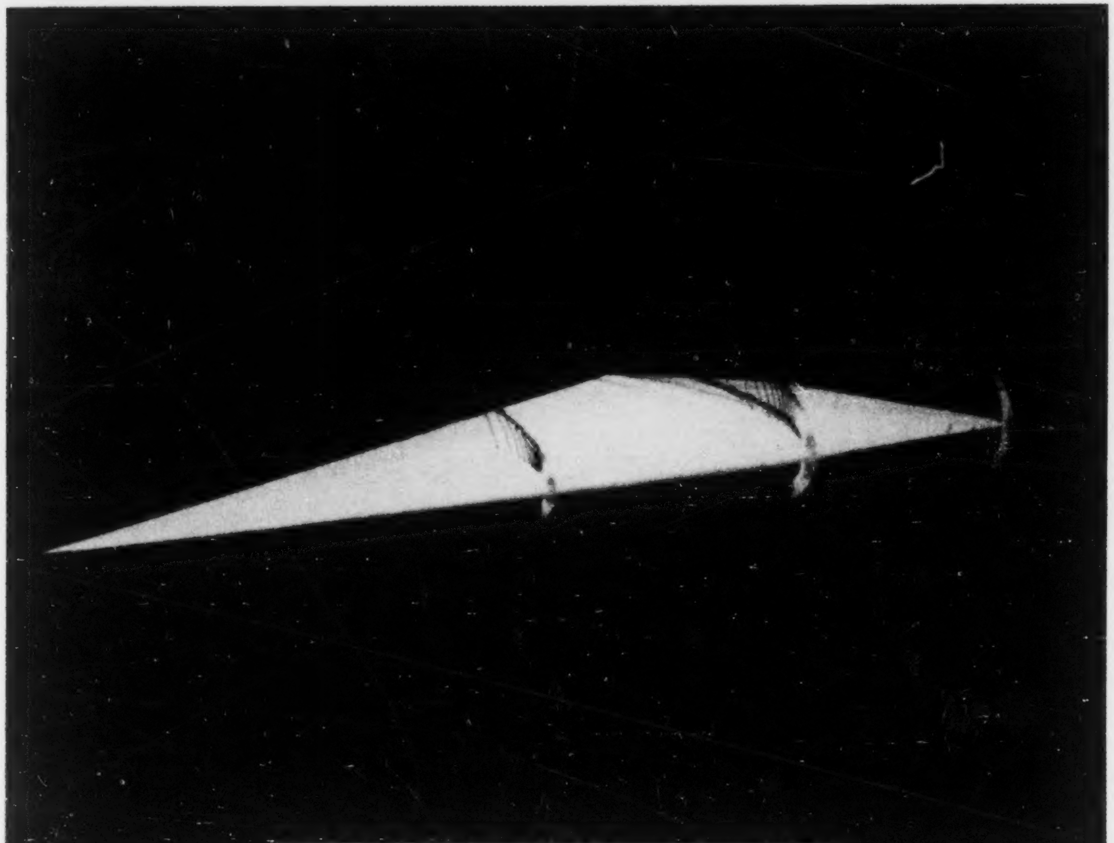


Figure 36. CFD Calculations of Mach Contours on Hypersonic Model

ly appreciate the contribution of the volunteer members of advisory panels. The interest and contribution of each member will contribute to the overall picture of the strengths and weaknesses within the NASA Aeronautics programs. Citizen participation is a cornerstone of this democracy.

I ask the representative of each advisory panel to convey my appreciation to every member of your advisory committee for the work that they are doing and have done in the past. Thank you, Mr. Chairman.

Mr. McCurdy. Thank you, Mr. Lewis. I certainly concur with those sentiments and we do appreciate the work that has been done by the volunteers, and they do it not for the money, because they love the subject area, and love science.

Our first witness is Mr. Harvey Album, Chairman of the Congressional Aeronautical Advisory Committee, and then we'll hear from Dr. Barnes McCormick, the CAAC Co-Chairman. Mr. Album, welcome. You may—if you have a full statement which you would like to have entered in the record it will be entered as will the other statements of the witnesses and you may summarize and proceed.

STATEMENTS OF H. HARVEY ALBUM, CHAIRMAN, CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE [CAAC] AND DR. BARNES McCORMICK, CAAC COCHAIRMAN AND PROFESSOR, DEPARTMENT OF AEROSPACE ENGINEERING, THE PENNSYLVANIA STATE UNIVERSITY

Mr. Album. Thank you. I will enter my introduction and the Committee's report into the record.

Mr. Chairman, and members of the Subcommittee, and other members of Congress who may later read this report, there are 4 main issues before you at this time in regard to aeronautics.

First, how important is aeronautics to the United States, fundamentally? Second, what are the trends and the status of our national air power? The third is, are NASA's aeronautics programs responsive to national needs, and to those trends? The fourth, is what changes, if any should be made in direction and scope of NASA's aeronautical activities to meet the national needs?

Now, there will be little need for debate or deliberation if the aeronautics is not that important, if the trends are fine, if NASA is responsive to those trends will be the case, or if there's not any need to change the direction or scope of current activities. Now these are the same four issues that our Committee dealt with, and I'd like to address each of these issues.

First, how important is aeronautics to the United States? Well we who have been working in aeronautics for so many years naturally feel it is very important. I'd like you to think about it for a moment from the standpoint of your own observations. We have crowded air terminals, packed with people, families going and coming, we have businessmen travelling from small towns and large cities all over the United States engaged in commerce and Federal Express picking up your packages at your door. By air freight, you can get lobsters anywhere in the United States from Maine. We are buying from and selling all over the world in terms of our goods. Little aircraft are flying up in the air. If you look up, it's a constant flow of traffic.

Basically aeronautics is, and air transportation is, central to the very fibre and core of our economy. The greatest effect is directly on the economy in that way, and not so much the economic statistics of the industry itself. I'll address those as well. In fact, 15 percent of all inner city traffic is by air, and I'm including automobiles. Ninety percent of all common carrier traffic is by air, excluding the local area commuter trains. There were 380 million passenger trips that were made in 1985. 75,000 . . . I'm sorry, 75 million general aviation flights were made in that year. Over half the traffic by air, on airlines, was for business purposes, and about three quarters of the traffic in general aviation was for business purposes. There are 225,000 civil airplanes in the United States. Therefore we have the effect of aeronautics on this great economy of ours for business, commerce and trade. It's impossible to measure the effect that that has on our country in terms of the economy.

But aeronautics is a basic industry itself. It goes beyond the effects of transportation on the economy. There were $47 billion in revenue for airlines in 1985 and $44 billion in sales by the aircraft and parts industry. The aircraft and parts industry employs 830,000 people. The airlines employ 410,000 people in the air and on the ground. So this is one of our prime industries. There you have the two basic effects. But most important is the prime effect of air transportation on the very fibre of our economy, and also the effect of aeronautics as a fundamental industry itself.

There is also the effect of aeronautics on the net balance of trade, which I learned yesterday for the first time was $11 million.

Mr. **McCurdy**. Billion.

Mr. **Album**. $11 billion; thank you.

Mr. **McCurdy**. Now, remember you're talking to the Federal Government now, Mr. Album.

Mr. **Album**. I know.

Mr. **McCurdy**. We're talking billion instead of million.

Mr. **Album**. What's decimal point here or there to the Federal Government——

[Laughter.]

Mr. **Album**. I didn't think it made much difference. Yes, it was that large and in the previous year it was about—it was about $6 billion. And so it has an enormous multiplier effect in terms of our commerce worldwide. Aeronautics is enormously important to the economic fibre and welfare of our people as well.

Now in the defense area . . . it's impossible to cover the total effect in the defense area. I addressed that somewhat last year in the report and in the Chairman's introduction,[1] where I tried to cover each individual segment.[2] Let's just look at it grossly for a moment. Military aircraft can be used for both conventional and strategic warfare. That includes both strategic aircraft and tactical aircraft. Ballistic missiles can be used only once. That's at the end of civilization--one time, one shot, one ballistic missile is the same as all of them.[3]

---

[1] Congressional Aeronuatical Advisory Committee Report to Congress in 1986.

[2] Military aviation sector.

Now you are engaged in the great debate that I know goes on each year regarding strategic defense, and it has enormous implications. The SDI initiative, let's think about that for a moment.

There can be no strategic defense without air defense. The Soviet Union has the capability to launch hundreds of aircraft against our country. With a new missile that they have, a cruise missile, that is capable of flying 1,800 nautical miles, they can penetrate up to 1,500 nautical miles into the United States. They have a larger number of tactical type bombers which if they were based in Cuba or in Central America would be a great threat to the United States. And so relative to something as important as the SDI initiative, just about equally weighted with it has to be concern about aeronautical defense.

Aircraft are extremely important to the defense of the United States. In fact the Department of Defense buys approximately $30 billion worth of aircraft and parts. That was the purchases in 1985. And so, aircraft are a very important element of our defense situation.

There you have the three of them, basically that aeronautics is enormously important to the economics, welfare and the defense of our country.

Now let's get to the second question. What are the trends in the status of our national air power? And that includes both the civil and military elements. There have been a lot of studies done by the Administration and by others as to what is occurring in that area. I'd just like to cite a few indicators to you right now.

Between 1980 and 1985, civil transport production dropped 43 percent. During that same time period, helicopter production dropped 73 percent, and general aviation production dropped 88 percent.[4]

Mr. McCurdy. What was the timeframe again?

Mr. Album. That's a five year period. Now this year, general aviation production is even lower. I think it was over—a little over 2,000 last year,[5] and this year I understand it's down to 1,500.[6] The effect on general aviation has been devastating. All single engine production except for one small company has stopped, that is single engine piston aircraft. Three of the largest companies have been sold off in one form or another. I think one of the other largest companies is on the block at this time, after very substantial losses.

At the same, during the same period of time, you had the growth of foreign competition. Incidentally, all of these changes here aren't related to foreign competition. A lot of them are strictly the economy and the inability to field aircraft that are so advanced that they outmode the airplanes that were there before them. You have to have significant advancements in order to justify the purchase of new aircraft, particularly in the case of the airline industry. And that's another aspect of the trends.

---

[3] Aircraft are far more flexibile and useful for varied situations.

[4] The annual sales of aircraft/production in the United States.

[5] In 1985.

[6] In 1986.

You know and we know that airlines have been facing years of losses. Somewhere there is going to be a bill to pay for this. We just cannot continue in that kind of a situation. The economics of aircraft affects the profitability of airlines, as does other things.

In the defense sector the situation is also not great. We have a gap, the gaps are narrowing and they are not in our favor. The Soviets have fielded a supersonic intermediate range bomber, which is essentially an intercontinental bomber. That's the Backfire Bomber. They have hundreds of those. We're just fielding our B-1 Bomber, which is heavier and it's intercontinental. But at the same time the Soviets are in the process of finishing the development of the Blackjack Bomber, which is intercontinental and supersonic. And so, we have a narrowing of the situation. The advanced bomber being built by Northrop is coming down the line, but it's a ways down the line.

In the area of helicopters, for example, the Soviet Union has developed a fighter—an air-to-air fighter helicopter—the first in the world. And they have the largest heavy airlift helicopter in the world. Their technology is first rate in helicopters.

We are in the process now, we are just beginning development of the advanced technology ATF, the Advanced Tactical Fighter. That's the first one in many years. If you don't count the development of the AV8B, we haven't had a new aircraft design in 10 years, over 10 years in terms of just being fielded. In the meantime, the Soviets have fielded three new ones.

And so we have a narrowing gap, and are engaged in the great competition here. We can't see, our Committee can't see, that we are not that far ahead, and in many places we're clearly behind. So the trends are not good. The gaps are closing and there are many places where the gaps are on the other side.

I forgot to mention the area of commuter airlines, where the foreign countries absolutely dominate the market.

That finishes the answer to the second question. What are the trends? The answer is not good.

The third question is: Are NASA's aeronautics programs and direction responsive to the national needs and these trends? If they are, and this is the thing we're addressing, then we really don't have much to be concerned about.

Let's consider the NASA aeronautics budget for a minute. By the budget, I want to talk about the total budget. There's a tendency just to talk about the aeronautical R&D contract budget. There seems to be a great focus on that, but the budget really consists of three parts. Each of the three parts is equally important.

The first is the Aeronautical R&D (contract) Budget. Now that contract budget goes to support in-house activities in NASA laboratories to buy things like models and support services and equipment, instrumentation, things like that. Then they have a portion of that budget that will go to industry to conduct original research. Roughly speaking they're almost evenly split.[7]

Then they have the Research and Program Management Budget which pays the salaries of the people. About 70 percent of this budget is for that. The other 30 percent goes for housekeeping functions like taking care of the lawns and the office buildings and such things.

---

[7] The split between the budget to support original R&D in NASA laboratories and by contractors.

The third budget component is the facilities costs. These include new facilities, modernization programs, repairs and so forth.

The total budget this year, sir, is $685.2 million, if you take out the Aerospace Plane.[8] That budget is roughly constant from last year. Roughly the same. We can discuss the Aerospace Plane I think, also. But most of my testimony, doesn't relate to Aerospace Plane.

Now the aeronautics budget' in constant terms' has averaged $700 million for the last 20 years. The inflator that I used in going back to look at the budget was the Federal Aerospace Composite Inflator. Anyone can find that inflator in the Aerospace Facts and Figures. So the total budget has averaged $700 million in FY '87 dollars. This can be directly compared to the budget that we have now. The budget was increased over that average during the 1977-1980 time period' by about $100 million. And this roughly coincided with the onset of both foreign competition, increases in airline costs and the fuel costs. Remember the energy fuel situation we had a few years back, the emergence of foreign competition, and the Soviet advances.

The budget has decreased since that time period by a $150 million.[9] In other words, the average from 1980 to today is $150 million below that short term increase. In fact, it has averaged about $50 million below the average expenditures, for the last 7 years. That's—that would be this last 7 years has averaged $50 million below the average for the last 20 years.

So the current budget before you now is about $15 million below the average for the last 20 years. If we look at the situation that exists, you have only one conclusion that you can come to. And that's that the overall level of the budget is not responsive to the trends because the trends have emerged since the late 1970s.

Yet if we look at the NASA program, we can see that there are many worthy programs that have been added to the budget during this period of time. You've had a view of many of them yesterday. Since the 1980s time period, human factors work has been added, and a lot of flight safety work. The human factors laboratory at Ames is extremely important, and this is in response to the problems with our national air space. The growth of transportation has led to crowding of our air space. The complications in new aircraft have made it more difficult for air crews to fly the aircraft. NASA is developing improved and more safe ways of operating aircraft.[10]

In that same time period, since 1980, we had the great growth of computational fluid dynamics, an extremely important opportunity to solve aerodynamic type problems that was brought about by the development of advanced computers. Now there's $65 million roughly in the R&D contract funds for this kind of work. If you look everywhere throughout the budget, that's about what it adds up to, and that's about 18 percent of the Aeronautical R&D contract funds budget. The figure approaches $100 million when you include all the NASA people involved. I don't know exactly what that number is, but it's somewhere between 65 and 100, and I would estimate that it approaches 100. And so, that work was also added.

---

[8] National Aerospace Plane Program.

[9] The NASA Aeronautics Budget total.

[10] NASA if focussed on elements in the aircraft's design and on-board systems.

During the same period of time, there have been a substantial number of flight test programs added, extremely important ones, some of them, such as the Prop-Fan program.

Now these efforts, and some others, like the new transonic facility that was added, the extention to the 40 by 80 wind tunnel, and simulators were added. And many efforts have gone into what I call a program mode. That's where things are aimed and ultimately you'll wind up with a demonstrator, such as the STOVL program.[11]

And so if you look at the presentations, and if you look at these things that have been added, you would say that they are just about all worthy. I mean, some people may differ with one or two. None of us ever agree on everything, but it's pretty darn worthy bunch of things that they've added to this thing, and we agree with these.

But you have to raise a question. Where did all these programs come from in a budget that has been remained constant, or decreased? How did that happen? It's obvious that somewhere, something had to give, because nobody gets something for nothing. Now basically what has happened here' in going over this budget in detail, going over the programs in detail over the last 3 years, it's very clear what's happened. The areas that have given are areas that should have been increased during this period of time in addition to the ones that were added, and that are the small innovative laboratory research programs. I call them applied research programs, a very broad base in the core areas of aeronautics. The core areas of aeronautics are structures, propulsion, flight control and materials and aerodynamics. Those are the most important ones.

When we look at these programs, we see that vast numbers of them have disappeared in a time period they should have been increasing. Now I do not fault aeronautics management for this. I want to get that straight, because things are a matter of priorities, and one could not say you shouldn't have cut those programs. You should have cut some other programs. You should not have put money in what you—you did put in. If we felt that way. We would have recommended changes. A switching of money from one portion of the budget to the other.

The fact of the matter is the real problem lies only in one place, that's a budget that is not responsive to what the needs are, and the cuts had to be made somewhere. So why were they made there instead of the large programs?

Well, for one thing, these kinds of small applied research programs are very hard to understand. They involve lots of different kinds of data. They involve sophisticated theories. It's very difficult to get up here and brief on a $30,000 program or $300,000 program being done by two people and so forth. But these are the kinds of programs that have enormous effects downstream in terms of creating new innovations in aeronautics, and they are the ones that have gone by the wayside.

---

[11] A short take off and vertical supersonic fighter type demonstration.

The weakest part of NASA's activities in these areas are general aviation, subsonic transports, propulsion for small engines, and propulsion for the next generation of turbofan engines with the ultrahigh bypass ratio engines. In other words—and another area is rotocraft, which has diminished quite a bit over the last several years. The rotorcraft work is very important, not only from the standpoint of our competitive position in civil rotocraft, but also from the standpoint of the relationships with the Army. They are very interrelated with the NASA laboratories.

And so when we look at this budget relative to the trends, we also have to say these areas which are very weak are the ones that are suffering the most at this very period of time.[12]

Another area which has not been supported is the area of facilities, NASA's existing facilities. NASA invests between 1.0 and 1.5 percent of the value of their facilities each year in modernizing their facilities, refurbishing them, maintaining them, and so forth. That rate of reinvestment implies a 75-year lifespan for the facilities.

Now 75 years is clearly an unrealistic expectation, and this has have created a substantial number of problems. Your facilities are not going to be nearly as productive for example, if you are not automated in data-taking, if you're not automated in your model-handling and things like that. A number of their facilities have had upgrades of that sort, in that way, and the results are very dramatic in terms of reducing costs. You know, in business you have to make some of those front-end faulities investments to get savings down the line.

Now we have seen a flow of paper[13] I was involved in some of this, too, in terms of assessing the importance of aeronautics and our aeronautics goals. There was the Administration study in 1982, which I was involved in as a reviewer, with an 'industry review group that I led, which pointed out that we must maintain superior military aircraft and field superior military—I mean, civil products, and that the health of the R&T base must be maintained and must flourish. We have had two National Goals Reports from the Administration on the importance of aeronautics and goals that we should be working toward.

The question before you right now is, what are you going to do about this, and what are we going to do about this as a nation. Are we going to continue going down the same path, or are we going to start a broadbased turnaround?

We struggled with that question. As you recall, in the two prior years, we did not recommend any increases in the budget above the submitted budget level. We recognized the pressures on the budget to date. The inclination of the members of our committee was not to recommend any increases, because the feeling was that we'd be treated as being unrealistic.

---

[12] The most serious problem areas in commerical competition, production and even serious military areas.

[13] From the Government on national aeronautics policy, the future of aeronautics and our national goals.

But in the face of these situations, in the face of what we're facing, we just simply could not do that. So we have presented the situation as honestly and as straightforwardly as we could, and that's basically what we say.

So let me go on from there. Now the problems, as we see it, in terms of what to do from this point forward, are more basic than just this year's budget. They're more basic than whether you add $25 million or $50 million, because we have seen changes before, and as I mentioned, the trend has been a long-term trend, and it's gone through two Administrations, so it has nothing to do with Democrat or Republican. It's a long-term trend.

This brings us to the changes that we recommend. They are too extensive to go over here. You can ask me questions and so forth. But I'm going to just hit the fundamental points, because there were some very basic thrusts involved here.

The first recommendation is that NASA should establish a Deputy Administrator for Aeronautics. I'm talking about NASA—the National Aeronautics and Space Administration. We look at the NASA organizational chart, and you'll see that the only person who has a singular responsibility, where he himself is solely responsible for the one area that of aeronautics, is three levels down from the Administrator. We think it's extremely important from an advocacy standpoint and a visibility standpoint and from an interaction with the other agencies standpoint, that there be one person whose sole interests—at a very, very high level—is aeronautics, in order to establish a proper balance.[14] This is even more important, since the aeronautics, budget is a small portion of the NASA budget. It is even more important, because it's easy for the agency, with all good honest intentions, trying to finish the difficult work it has in space' to not pay attention to that "other area." And that's why is so important.[15] It's not expensive, but it's important?

The second one [16] is that NASA should realign its organizational process to provide greater emphasis and focus on aeronautics. Now we're purposely not specific here, because we believe that realignment is something that the Deputy Administrator should look at when he takes over that job, that he should converse with and work with his own people, so that there is a proper flow of work, and so that the fundamental objective that we have asked for is instituted by NASA and not by an outside group saying, "It should be this way or that way."

Third, we recommend that NASA establish a strong-based innovation research program. Now what I mean by "innovation research program," is a program that is aimed at specific improvements in aircraft. I'm not talking about methods. I'm not talking about flight test type work. I mean very core type activities, small applied research projects, in which people come up with new concepts, in which radical innovations are encouraged and where there is fairly freethinking. These are the kinds of programs that NASA had enormous numbers of in the past, and they had a big effect, particularly in the '50s when NASA was NACA. These should be programs on the order of $100,000 to $300,000 maybe at most, with maybe one or two researchers, and they should be spread broadly across the areas of propulsion, structures, and so forth, in the core areas of aeronautics.

---

[14] A proper management bullance in the NASA between it aeronautics and it space as activities, which are given given equal weight as NASA's missions in the space act of 1958.

[15] The recommendation for a Deputy administrator for aeronautics.

[16] The second recommendation.

The fifth recommendation is to increase NASA's in-house laboratory capabilities. Now I'd like to really stress this part of it. We visualize that most of the increases, if not all, that we have recommended in contract funds should go for in-house programs. I know there is a tendency in the Government to say, "Industry can do it better." There are many things that industry can do better, but NASA's laboratories have been superb in their ability to do the kind of work that I'm describing. They have the right kind of environment. They have the right kind of interaction. They have the access to central expensive facilities. It can be done long-term, which is very difficult for universities and for industry to do.

Universities don't have the applied environment. They do the basic research—more basic type work. And so this is exactly the place to do that kind of work.

Along the lines of improving their capabilities for innovation research, we recommend an increase from FY '87 levels of 102/NASA research staff members.[17] We went through the budget; we went through the individual programs, program by program; that's how we built up that number.

Now the sixth recommendation is to increase NASA's laboratory flight test capabilities. Here, the specific way in which they must be increased is to increase the number of people. The NASA people in flight testing are very, very spread, very thinly spread. In order to increase the output of those facilities and the output of those programs timewise and the quality of the work, in terms of documenting it, and so forth, 47 people should be added to the number they have now. This would have a very large effect. We're looking for multipliers in all these recommendations, high-level, high-leverage multipliers.

The seventh one is to increase the investment rate in NASA's existing facilities. The committee believes that it should be at last three percent of the facilities' replacement value. Some say it should be five percent, based on industry standards. But the overall recommendation is for three percent.

Now we have recommended increased funding and people on 22 programs, and you'll see them very spread throughout the whole budget. One of the reasons for that is the exact orientation that I'm talking about, because it's spread over different kinds of programs, from subsonic transports, general aviation aircraft, propulsion, and so forth, and it's also spread very widely because of the kinds of programs that we're requesting and recommending that you go forward with. These are small programs with small numbers of people.

---

[17] Referring to NASA laboratories for applied research on new innovations for aircarft components and concepts.

So in conclusion, let me say that these recommendations may seem relatively modest in cost, particularly when you deal with the big space budget. They may seem relatively modest in the number of people. But, we believe that this would be a very substantial step to begin a reversal of the negative trends that we're facing.

Thank you, Mr. Chairman.

Mr. McCURDY. Thank you, Mr. Album.

Dr. McCormick?

Dr. McCORMICK. I want to thank you for the opportunity of appearing before the committee today.

Let me start by saying that I believe what I just heard Harvey say and what I read in his report of record is a true reflection of the concern of the rest of the committee for the present status of aeronautics.

We think that NASA needs to get back to more emphasis on that first "A" in NASA, and a good way of doing it would be to designate a deputy administrator who would be a true advocate for aeronautics as opposed to the other interests in NASA.

He talked about the current state of aeronautics in the United States. We are seeing inroads being made into the transport industry. We are seeing American air lines buying the air bus and other foreign transports. If you have flown on a commuter recently, you probably took a flight on a boxy aircraft made over in Ireland by the Short Brothers, or maybe even one made down in Brazil.

The people in Lakeland, Florida, for example, will certainly testify to the dire straits of the light aviation industry right, as will those in Lockhaven, Pennsylvania. Of course, some of that is due to the litigation problem that Congress is trying to resolve, but I think a lot of it is due to the fact that the typical light aircraft of today looks just like it looked when it was built back in 1940. The same kind of typical semi-monococque construction. We are beginning to see a little bit of composites being introduced, but there are a lot of advances in propulsion aerodynamics that could be brought forth and applied to that class of aircraft.

In the rotary wing field, we saw the U.S. Coast Guard buy a French-built helicopter after a competitive evaluation. If you look at the EMS, the Emergency Medical Services, you see it dominated or at least a large number of EMS helicopters are the MBB, the German-built Messerschmidt Boelkow Blum.

I personally had an occasion where I was considering, on a sabbatical leave, going to work for the Army's technical activity at Ames, and one of the things we were talking about me doing while I was there was to help assist in some noise measurements that were going to be made by the Army in the DNW tunnel, which is a tunnel in Holland. This country does not have a good acoustic wind tunnel. I think it is a sad state of affairs when the U.S. Army has to go abroad to obtain something as important as noise data on a helicopter.

With regard to innovation, Harvey I think you sounded a little harsh. There have certainly been a lot of programs in NASA that have displayed a lot of innovation. We are seeing the ATP or the Advanced Turbo Prop program now beginning to bear fruits. Now probably the next generation of subsonic transports will be powered by what I call a propeller, but the sales people don't like to call them propellers.

At any rate, that is a direct result of innovation which was started at NASA Lewis. At NASA Langley we are seeing natural laminar flow work going on, drag reduction in general, which is certainly innovative in nature, the spin resistance studies that were done on light aircraft by Langley, and the computational fluid dynamics work in the just-dedicated NASA facility are all good examples.

I think we need to see more of that kind of thing, and the only way we are going to do it is to give them more money and to give them more facilities. That money should go for not only people, it should definitely go for more people, but it has got to go for improved facilities and for maintaining and upgrading the present facilities.

The details on these are spelled out in Harvey's report of record. So I think about all I can do is second what Harvey has already said with those few additional comments.

Thank you.

Mr. McCURDY. Thank you, Dr. McCormick.

Gentlemen, we, the full subcommittee and, I think the full committee of the House recognize the hard work and amount of detail that you have put into this budget and the recommendations that you have made regarding the changes in structure and some general recommendations in the direction of perhaps placement of emphasis in the aeronautics arena, and we appreciate your efforts.

This is a rare advisory committee in the Federal Government. Some of us have been looking at it as a model for some assistance in the SDI arena and think that there might be some benefit from that, but again I want to extend our appreciation to you for the amount of work that you have done. We don't always agree, but I have been married for 15 years, and we don't always agree either, my wife and I.

It is interesting, Dr. McCormick, you mentioned the fact that aircraft has changed very little since some of the early designs. I have a photograph of my parents, who were members of the Flying Farmer organization, standing in front of a Taylor craft in the late forties, and it is true aircraft has not changed much since those early days.

It really brought up a question I had with the plight of general aviation. Of course, those of us in the Southwest understand the energy picture probably has much to do with that, as do the interest rates and some of the other factors. How would you refute the argument or rebut the argument that perhaps in general aviation, since aircraft has not worn out for general purposes, that perhaps we just have a saturation of the market? How do you respond to that?

Dr. McCORMICK. I think to some extent that is probably true because I have seen one firm just start up recently whose sole purpose is—let's see, what is it called. I think Zero Time is the name of the outfit. They take used aircraft and turn them out like brand new again, and they can do this at about half the price of current aircraft.

But I think the point is that these aircraft flying around would become outdated and outmoded if we had new ones coming along. It is like a 1988 car model coming out. People want to buy the newest things. I think if we could inject in light aircraft design some of the advances and things that we are seeing right now, that we would begin to stimulate that market, and some of the older airplanes flying around which maybe shouldn't even be flying around would be put to rest.

Mr. ALBUM. Let me give you an answer to that question to illustrate his point. We have two recommendations in our budget along these lines. One is for work on a general aviation cockpit, a cockpit that would be user friendly, using advanced digital electronics and computers. One person on our committee, I think pointed out—he said there is more technology here in my digital watch than there is a general aviation cockpit.

If you have a cockpit that is going to be user friendly in terms of the crowded air space environment, to make it more safe to fly, which makes it possible for pilots to fly easily on IFR-type rules and so forth, you are going to attract more people into the cockpit. That is one of the areas that we recommended some work on. That could be done in simulators. NASA has the capability not to do all that but to do some of the early innovative things that will set the avionics companies moving along. That is what NASA has traditionally done.

The second recommendation in a fairly good budget, I think, for general aviation is work on engines. I think, Mr. Lewis, you know that engines are the things that have always made the really big differences in aviation. I am an aerodynamicist, so it is hard for me to say that, but it is true. The big advances have come from changes in engines.

We have money in the budget for both advanced turbine type engines but also the Wankel engine, which is being worked on at Lewis. It would makes quite a difference to the small, single-engine type aircraft.

So if you get big enough changes in the capabilities of an aircraft in terms of range, in terms of user friendliness and safety and so forth like that, you are going to have these older aircraft outmoded. There can't be just a 10-percent change. It has got to be enough to really make it worthwhile.

And who benefits from this? The American public benefits, not just the selling of the aircraft, but the people who fly in it.

Mr. MCCURDY. You mention on page 6—there was a little typo that confused me for a minute, but you call for a deputy administrator for aeronautics, and the deputy administrator should be responsible for all aeronautics programs in NASA. Since you are an aerodynamicist, as you call it, you had aerodynamics, deputy administrator for that, but you are talking about deputy administrator for aeronautics, that he should be in charge of all aeronautics.

I understand your point for emphasis, but is that not just moving boxes around on the organizational chart?

Mr. ALBUM. We don't feel that that is true. It could be if you moved the box from one place to the other on the same level or cut the pie a little differently.

Mr. MCCURDY. It depends on who is in that box.

Mr. ALBUM. Yes, that is part of it, too.

Mr. MCCURDY. That is my point all the time.

Mr. ALBUM. That is part of it. But we basically feel that there should be a person at a very high level whose sole focus is on aeronautics. I mean he is thinking about aeronautics programs. He is thinking about nothing except aeronautics, his relationships with other organizations and how they fit in, and he is in very close contact with the administrator. He is overlooking the budget. He is the guy that interfaces with Congress or whatever.

We are not saying there ought to be a change, incidentally, in the current people. What we are talking about is a position and not a person.

Mr. MCCURDY. Well, what we were saying, Dr. McCormick, is that you can change the organization all you want but it is critical to have the right people. We are not criticizing the current deputy; what we are talking about is the need for, I guess, prestige and the ability to influence decisions.

Mr. ALBUM. In our discussions, a number of the committee members mentioned this as well. You want to have a stimulative environment in the NASA laboratories, and in discussions that various committee members have had over the years and recently with people in the NASA laboratories through their personal contacts, they kind of feel like they are sort of under the gun, that the way to get ahead, you know, professionally is to be in space.

This would create clear line, clear set of objectives with very clear leadership, and hopefully, we are trusting that the right person would be selected for that job and it would make a big difference.

Mr. MCCURDY. We have the same problem, of course, in the Congress or any organization, whether it is armed services or—the strategic systems seem to get more attention than do the foot soldiers, and it is where the technology is, and the Space Committee has probably 20-some odd members, while this subcommittee is smaller. It is not that it is less important; it is probably the attraction. It is the level of attention. I certainly understand where you are coming from.

Dr. Colladay mentioned previously that there was enough laboratory work; that what you really needed was validation phase. Do you differ with his position on that?

Mr. ALBUM. There we have a fundamental difference in opinion, I believe. I am not sure that he meant it exactly the way it sounded there. I was here when he mentioned that. There is a tendency when you think about the budget or think about management to want to stress one or the other. The truth of the matter is everything has its place. There are areas where clearly NASA needs to forge ahead all the way into demonstration.

An example of that is the rotor and the propfan—absolutely superb programs both of them, and properly done. But do you want to have all of those kinds of programs or 90 percent of those kinds of programs? Well, you aren't going to have that early stuff that led to the propfan. The propfan started in 1975. People were sitting around doing very small early tests earlier than that to show that the thing was even feasible. That is the early innovative program, and you had lots of those of that sort.[18]

You are going to have a guy speaking here a little later, a friend of mine, Norris Krone, who performed—he did his doctoral thesis on forward swept wings. The question that he was interested in was can you sweep wings forward because there are some advantages in, for example, geometry and the how the aircraft is laid out, just simply being able to open that design space.

He conducted his thesis, and he showed that you could swing wings forward with acceptable weights. He spent about two years doing that, and if you look at the budget, his time and so forth, maybe it was $100,000.00, somewhere in that vicinity, one man. Now you have the X-29.[19]

It is from those early things. You have to start somewhere, and you need lots of those programs. There used to be guys at Langley that were working on aft ends of aircraft, the interference, the effect of two engines. The fellow's name was Runkle. Excellent work. He looked at all different configurations. That is one of our biggest problems, is the propulsion integration problem. You need people doing that. He was trying to figure out what is a really good way of doing this. In some cases, by placing the engine properly, you can get better than if you had a single engine. There are actually locations where you can do that. You need large numbers of people doing that kind of thing that are going to lead to stimulative advances in armaments.

The great thing about it is that it is not expensive at that early phase, and if it doesn't work out, you haven't lost that much. Then later when you see that it has a big payoff, that is when you jump in and you focus on getting it into application.[20]

Mr. McCurdy. Thank you, Mr. Album.

I will look forward and I think the committee will spend a great deal of time on the recommendations and be considering them carefully in our markup deliberations.

The gentleman from Florida.

Mr. Lewis. Thank you, Mr. Chairman.

I would like to dwell, if I could, Mr. Album and Dr. McCormick, on general aviation a little bit. I am very much interested in this, and in fact I am astounded by a couple of the numbers that you have. I didn't think it was quite that bad, 88 percent down in five years. That is unbelievable.

But let's just talk about trying to make flying simpler for the average pilot who would be instrument rated and things of that nature today. That is one of the reasons that the costs of airplanes are so high, because of the avionics that we have. Though the aircraft itself hasn't changed, the design, the fuselage has changed too much, but the engines are much better, but the avionics are so much better but so expensive, which really prices an individual out of the market unless it is a corporate purchase for the aircraft.

---

[18] The results of the vast number of small innovation research programs go straight into use by industry without the need for costly NASA demonstration programs.

[19] The X-29 is a DARPA/USAF/NASA experimental aircraft with forward swept sings.

[20] The transition to application is best done by industry and the military services generally. In some cases demonstration or "validation" experimental hardware programs may be justified by NASA, but then usually as a partner to the military or industry.

How do you envision that we could get the costs down so that you could get into a situation where—actually, you are talking about a little bit above the average pilot when you are speaking of flying instruments and that sort of thing. Piper is an example. It costs them $73,000.00 a year now in liability insurance for every aircraft they have that is flying, and some of them are 30 years old or more.

How do we get into a cost situation here?

Mr. **Album**. To be honest, technology is not the big driver. It is a factor. I believe it is not the big driver. The big driver, as you are talking about the liability, is a legal one, the liability overhang. Technology will have an effect, the first effect being, in this case of liability insurance, getting safety up. If you have a more user friendly aircraft that a fellow is able to fly better and it has more capability at a reasonable cost.

The point that you make about costs in avionics is quite true. Costs go up pretty fast when you put some kind of a navigation system in there, and pretty soon the costs are going up. But your technology can even improve the costs. I like to cite, for example, LORAN C which is being used now.

Mr. **Lewis**. An excellent system.

Mr. **Album**. Yes. You know, six years ago I was advising a company to go in that area, an avionics company, and they said, oh, yeah, it doesn't cover enough of the country and all that sort of thing, and now they are having trouble with the ones they are trying to sell because they are getting outmoded by LORAN C.

So there are things that can be done in technology that are cheaper if you have got that in mind to start out with. There are things that could be done. What we are saying is that you want to spend small amounts of money in exploratory fashion to seek those things, and put good, smart people on it. If I knew the answer in advance on each area, I think I would be a pretty rich consultant.

Mr. **Lewis**. True.

I would like to ask you, Dr. McCormick. You were concerned about helicopter noise, and we had to go to Holland to come up with the data that we needed for helicopter noise. I am not all together sure that is wrong that we don't have a wind tunnel that can handle that situation. I would think that by the use of the technical ability of other countries as well as our own in an area—I'm not speaking of DOD now, speaking strictly in the area of general aviation and commercial aviation—that we are further ahead to some degree by using their facilities rather than spending money to construct our own when we can use that money better somewhere else. I don't think we have to be in the lead to do this.

Dr. **McCormick**. Of course, it is not just DOD that uses the DNW tunnel. All of the helicopter manufacturers, Sikorski, I guess Vertol does, I know Sikorski, Bell uses the DNW acoustic tunnel because it is the only one around. It is a question of, just like on a small scale at the university we like to have our own machine shop instead of a central shop, where we have control, where we can go to, where we can control the scheduling, where we can get a priority, get into that tunnel. If a company wants to go in and run a test, like the Army, they weren't exactly sure when they were going to get there. They were worrying about my schedule fitting theirs and whether or not they were going to really get in that tunnel at a certain time or not.

It would be so much more efficient if we had a facility like that in this country where we could exercise control over it.

Mr. LEWIS. Don't we have the same type of scheduling problem with our own wind tunnels?

Dr. MCCORMICK. Yes.

Mr. LEWIS. I have tried to get projects in wind tunnels and have to wait 18, 20, 30 months before I could get in.

Dr. MCCORMICK. Of course, the 40 x 80 tunnel was down and it is just getting back in operation. That created a backlog of work in that area. Then we have had the 12 foot tunnel, that one that has developed all the cracks in the welds and everything, which has created another crisis. You are getting these indications that the stuff is wearing out.

Mr. LEWIS. That is true that we should upgrade what we have. We are not doing a very good job of that.

Let me go one bit further, and maybe, Dr. McCormick, you will want to address this. Why should we to any great extent be involved in upgrading general aviation as far as from the Federal level? In the past most of the things in NASA when it initially started, the general aviation gained from their research and development, but is it our responsibility to upgrade the Piper and the Cessna and the Lear folks so that they can compete with the foreign competitors?

Dr. MCCORMICK. No, I don't think we should attempt to upgrade them to compete, but I think we should supply them with the basic innovative, new type of data and material, theories, whatever that will allow them to maintain an edge or keep even with what we are seeing.

Mr. ALBUM. I would like to expand a little bit on that. General aviation aircraft are used not only by the civil sector; they are also used by the military sector. Very large numbers of these light aircraft are used by the Army for spotter plane purposes and things like that. They are used for training.

The programs that we have recommended along those lines, for example, the light turbine engine program, those aircraft would not only be used for turbo-prop single-engine type things. It can also be applied to helicopters. There is a great deal of overlap, basically, in the programs that we have recommended, and so fundamentally what you have is a situation where you are helping civil aviation, and at the same time you are helping the military component that benefits from it as well.

Many of the things that you do there, for example, the cockpit concept that I was describing, that could be applied to a military version, too. They just buy it off the shelf, fundamentally, once it is there. So it has very great benefit, and it is not very large amounts of money, and it has the same stimulative effect on the economy as helping Boeing or whoever with the larger amounts of research. Then you have the overlap there, as well, with civil and military transports.

I know that there have been two occasions where some people in the government, which I don't believe included any of the present company, thought you could cut the NASA budget in half because it must be roughly half military and half commercial, and it just doesn't work that way. You just can't find the commercial segment. You may find little pieces of it here and there.

Mr. Lewis. You never asked for an increase, recommended an increase on the NASA budget in the past, and you have this time, and did I understand you correctly that you feel now is the time, that you have held back long enough, and you feel——

Mr. Album. You know, the deliberations—you should have been there. It was pretty fiery. We have in the past felt the weight of the responsibility on the budget thing, and, as engineers, I think they were very conservative in the changes that they have made. They were nickel and diming each other, going right down the line. Guys would say, oh, I think we ought to double the number of people here, and they would get half of what they thought was the right number. So they went through it, and that is why it is so detailed in going through the thing—The numbers were built up from there rather than just saying, look, we have to have $150 million.[21] The $150 million number came from roughly the level in about the eighties, which is a matter of perception that we were really starting to move forward, the early eighties and late seventies.

So what is the exact number? I don't know. Maybe it is $300 million, maybe it is $150 million. We know that it is not where we are now because the trends are not moving fast enough, although there is good work. It is very easy for somebody to criticize—a speaker here, my vice chairman—criticizing the chairman and saying you are saying there is not enough innovation, and how about this and this? We say it is fine, what they are doing is very good, and we just need more of it.

Mr. Lewis. How did you really derive the need for—for a 150 additional positions in NASA? 150—how did—did you just pull something out of the air?

Mr. Album. Well, the 150 was frankly rounded off. We came up, I think, with 137 or something like that. And what we did was to go through each element of the budget, and we looked at that element, and the people that were in it.

Incidentally, you have to subtract out the facilities people. You do something like, you look at applied aerodynamics and you see an enormous number of people. And you need people to run the facilities. They're all in there. You've got 200 and something people. When you get down to the actual number of researchers you find that you've got a small number and they each are spread over three or four different topics.

And we deal with these guys on a regular basis. And so, the knowledge of the programs, the knowledge of the numbers of people involved, and also, we had briefings on what the outputs were, and we said, look, we think we need twice, you know, if they had five people, we thought they needed twice that many, so it would be ten.

In some cases, it was ball park as for example, the number of people in flight testing. The point was made that the flight test rate is about, roughly, one a month or something like that. Is that what it was, one a month?[22] And that industry does it at five a month, five flight tests a month. And it's not that they're dumb; they're bright. They just haven't got enough people. And also, the committee was very critical of the output. Basically, they weren't documenting these things fast enough and well enough.[23] And the people just hurry, rush around' trying to get things done. So, they said, well, how many more people do they need? We had a vote on how much should we increase it, 10 percent, 20 percent, 30 percent; and they agreed on a percentage. Then, I had to go through the numbers after they left to figure out how many people were there.[24] It was a perceptive thing.

---

[21] Increase above NASA's submitted budget.

If you wanted to vary the numbers, you know, five people or so, either way, on a big amount, you'd probably be as right as we were. But in small amounts, in some programs they said three people, and they knew the exact program. Like in the case of vortex, wing Vortex work, it would take about three people at a million dollars for them, wind tunnel models and stuff like that. And that's the right number of people to do it.

So, we built it up, and then I rounded it off.[25] It didn't seem right talking about 132 people.

Mr. **Lewis**. Thank you, Mr. Album and Dr. McCormick.

Thank you, Mr. Chairman.

Mr. **McCurdy**. Thank you, Mr. Lewis.

Mr. Album, I—maybe we can reverse roles here, but I—with my colleague, and I'm not sure people understand how difficult this budget year is going to be. It is going to be the most difficult that I think my colleague and I have ever faced since we've been in Congress. And the options are very limited, and certainly very narrow, and attractive.

If I were to pose a very difficult hypothetical question and that is, within the total NASA budget you had to reprioritize, how would you get your money for the increase that you're asking for?

Mr. **Album**. Well, you've asked me a difficult question, and one that I really don't feel expert to answer. I can only look at the space budget as an outsider. And I look at the space budget and say, boy, that is big. And I look at the aeronautics budget and I say, that's pretty small, only 7 percent.[26]

When I look at the increase that we have recommended, it's even smaller and I think what the effects of that the increase would have. Because, those guys feel it would be really strong,[27] It's put in those early areas that we asked for, that we recommend. And so, it is a very perceptive thing.

But I would be stepping completely out of my capacity and capabilities to say you ought to cut this space program and that space program. That's one issue that I think you'll have to face with your colleagues. I wouldn't be in, I've got to throw that one back to you, because I'm not, you know, it wouldn't be correct for me to say that you've got to cut some space program.

---

[22] Question directed toward the advisory committee cochairman, Prof. McCormick who indicated the figure was correct.

[23] Referring to NASA's flight test staff.

[24] In flight testing at NASA.

[25] Considering each individual program and the people involved, and then rounding off the total number.

[26] Of NASA's total budget.

[27] Referring to the advisory committee.

Mr. McCURDY. Do you think the funds for the aerospace plane should come at the expense of traditional aeronautics?

Mr. ALBUM. That's a very important question to ask. You know, we didn't address the aerospace plane, and the reason we didn't address it in terms of the technologies and that sort of thing was for two reasons. One was that about three-quarters of our committee is involved in it, in one way or another, and had a conflict of interest.

Now, the other . . . think was two-thirds roughly. The other third thought they were very competent to do the job, but the first two-thirds didn't. So, the result was, we didn't address it with one-third. We basically didn't address it at all.

But we did address that issue, the very issue that you brought up. If we are concerned about the trends that I have outlined, those are very specific trends. They deal with helicopters; they deal with general aviation; they deal with transports; they deal with the military sector for aircraft fighters and bombers, and this sort of thing. Now, the payoff for the aerospace plane may be quite profound, but it's not going to affect any of those things. It may affect the, in some ways the strategic thing. I'm not close enough to it myself to be able to tell you. But the technologies involved there are very specific technologies.[28] The requirements for them are primarily, that it's operating under reentry conditions, a good deal of its flight. You know, that it would use using scram jet propulsion; a completely different kind of propulsion that an aircraft use. Its got materials problems in terms of temperature that are really extreme. The technology for the Aerospace Plane would not benefit the otehr sectors of aeronatics or the negative trends we have been discussing.

Mr. McCURDY. Can you pull that other microphone over. That one appears to be cutting out.

Mr. ALBUM. Is this one working better?

Mr. McCURDY. It seems to right now. Just keep kind of looking in that direction, perhaps——

Mr. ALBUM. Maybe I ought to put it in front of me.

And so, it has very special type technology problems that are completely different than the kinds of problems for aircraft type situations. Other aircraft have enormous overlap, you know, the ones that fly in the atmosphere, That's where a lot of the methods are developed, as say for rotorcraft, can also be used for other types of low speed aircraft. A lot of the techniques are very common. And so, when you look at this investment which you have in these fundamental areas which overlap quite a bit in terms of the aircraft, and then you have the enormously special program of the aerospace plane. And so, when you're investing in one, you're not affecting the other. That's what I'm saying, the amount of overlap is very small.[29] And if you want to affect one or the other one, then you have to put your investments there. Equally so, when you put your investments in the first one, you know, the basic work that we're talking about, you're not helping the aerospace plane all that much.

---

[28] Referring to the National Aerospace Plane program.

[29] Referring to the aerospace plane.

So, you have to make these determinations, I believe, I would submit, separately, independently on their own merits, and not expect an overlap.[30]

Just to categorize them as aeronautics, which you can, you know, you can argue it's a semantics problem. But, you have to look at what the end output is, in terms of what you're trying to affect in the end. That's why I recommend that you separate those two determinations, and that's our recommendation of our committee.[31]

Mr. McCURDY. Your committee faces the same problem that Congress faces, too, that one wing of it doesn't feel that they're competent to judge, but it's always the other person's pocket they want to cut or someone else's programs is boondoggled and theirs is vital to national security.

Anyway, we appreciate, again, the work that you've done. I think in the interest of time we need to move on, and we're going to call the next panel, Dr. John McLucas and Dr. Norris Krone. I think we can have them appear jointly; and then we'll have Mr. Andrews and Mr. Koven later.

Gentlemen, Dr. McLucas, Mr. Secretary, former Administrator—you've had many distinguished hats you have worn in the Federal Government—former Secretary of the Air Force and Administrator for FAA, and we certainly understand and appreciate your vast experience in these areas and look forward to your testimony on behalf of the Commission on Engineering and Technical Systems, National Research Council and as Chairman of the Board of QuesTech.

I've always wondered when I've driven by that building out there in McLean who was officed out there. I guess we now know.

STATEMENTS OF DR. JOHN L. McLUCAS, CHAIRMAN OF THE BOARD, QUESTECH, INC. ON BEHALF OF THE AERONAUTICS AND SPACE ENGINEERING BOARD, COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS, NATIONAL RESEARCH COUNCIL; ACCOMPANIED BY DR. JAMES KRAMER, CHAIRMAN, AND DR. ROBERT KORKEGI, DIRECTOR; AND DR. NORRIS J. KRONE, CHAIRMAN, ADVISORY COMMITTEE ON NATIONAL AERONAUTICS, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS AND DIRECTOR, UNIVERSITY RESEARCH FOUNDATION, GREENBELT, MD

Dr. McLUCAS. Mr. Chairman, thank you. Incidentally, I've only been at QuesTech, Inc. a few months, so I'm a newcomer.

I'm very happy to appear here today and present on behalf of the Aeronautics and Space Engineering Board some of our views on the NASA aeronautics budget. I have been on this Board for two years, but we do have some old hands here, though. We have Dr. Jim Kramer, who is actually Chairman of the Board right now, and Dr. Bob Korkegi, the full-time Director of the Board, and we may call on them if you have questions.

---

[30] Efforts on just the aerospace plane relative to the broad spectrum of overlapping progams needed for other types of aircraft.

[31] Effort on just the aerospace plane relative to the broad spectrum of overlapping programs needed for other types of aircraft.

I should state that in my role here today, I'm supporting an ASEB position. In other words, I'm not speaking my own views. I'd be happy to talk about those on the side.

But what we did was, we convened a group of the ASEB members to decide how we would respond to your request, and so we're speaking here as a representative group.

I think the main point that we would like to make is perhaps not very different than the one you just heard from the other group—namely that we have to have a strong aeronautics R&D program in this country. We must support our own domestic needs, and we must support a strong foreign sales program because of what the aeronautics industry has done for the balance of payments and our trade position.

I won't go into detail. My full statement has some background on how long the ASEB has been doing this kind of work with NASA, how we work with FAA as well as NASA and with the Air Force and other bodies of the Government. There's a lot of detail in there about this.

I think one point that is interesting is a list of reports that we have published, which is attached to my statement at the back. It's roughly two special studies per year that we have done at NASA's request, and we've invested quite a bit of time and energy in the preparation of those special reports.

We meet two or three times a year with Ray Colladay and his staff and review the overall NASA programs. For example, we have recently met at Langley, at Ames, at Lewis, to see what's going on there and to have a firsthand impression.

As an example, about one year ago, we met with NASA and looked at the upcoming budget cycle and what the technical programs were that they would concentrate on. We met with them again in April and again in June, as they updated their views of just what specifics would be included.

So we feel that we're in quite close touch with NASA's R&D program. At the same time, I should point out that we did not get down into too great a detail. We're looking at the broad sweep. We want to see if they're putting their energies in what we consider the broad important areas, and not looking at specific program detail.

Going back to the National Aeronautics and Space Act of 1958, I think we're all impressed. I have certainly been impressed over the years to keep that Act in the back of my mind as I look at our position in aeronautics and space science and space applications—namely, a role of leadership. It was much easier in the early days to maintain that lead. In recent years, it's become much more difficult.

So when we point out NASA's shortcomings, it's not because we don't think they've been doing a good job, but because we think the race is getting tighter. Therefore, they've got to do more in order even to stay in place.

The world picture has changed a lot in the last five or ten years. We were once the dominant power; now we have all the things that we've heard about that are affecting our position in aviation—and space, too for that matter.

Looking at the 1988 budget, our conclusion is that we have no major differences with the thrust of that budget. The only problem we have is the level of effort.

Now I do point out some specific areas where we think more effort is needed. In other words, we're not just saying, "Spread more money across the whole board." But one thing that has struck us is that there's no growth in the budget over the last several years in the aeronautics area, except a little bit to try to keep up with inflation. And we think, in view of the increasing seriousness of the foreign challenges that we face, that's not adequate.

There are certain basic areas, and I think they were pointed out by the previous group, where we have to examine the R&D budget every year, and these areas are the same every year—the propulsion area, the structures and materials areas, drag reduction, things like that.

There's one new area lately which we think is a highly significant one that does require special attention, and we have given it special attention, and that's the computational fluid dynamics area.

In addition to these basic areas which are always there, in our submitted statement, we point out a few areas that also need attention. The most specific one is the aging of facilities and the need to repair those facilities. We have some points about air safety, some comments about general aviation, and the relations between NASA and the academic world of research and development.

To go to these specific points—I mean, the points related to the general areas which we always support—to start with aeropropulsion, NASA is just finishing a round of programs that were related to turboprops, and we thought that was a very successful effort. It seems that as those programs get finished up, that NASA needs sort of a new thrust as to where they go next, and we have not seen a program that would replace the existing program, which is just about finished up.

So we're very anxious to see what NASA will come up with next, and when we say NASA, we believe they can't come up with an appropriate program without involving the Air Force, industry, and university people who are knowledgeable in the area. So we are ready to look at any such program which they put together.

In the field of drag reduction, NASA has demonstrated some interesting developments in hybrid laminar flow, and we think that that's got much promise for improvement in cruise efficiency, and we applaud what has been done. But this is still a very high-risk area. Many of the specific designs that have been demonstrated, there's doubt about whether they're practical for putting into commercial use yet, and so there has to be a continuation of what NASA has done, and we see the need there for a large-scale flight demonstration program that would prove out this drag reduction technology, which appears very promising.

In the materials area, NASA is cancelling a large composite structure wing. We don't disagree with that. We think it was very specific to a particular design, which may or may not be the best. We have looked at this area, though, and we have some other suggestions for NASA, some details that we would propose that they do as a replacement for the composite program which they're working their way out of.

We think composites have great utility in almost every type of airplane, and that research in this would pay off.

With respect to the new area that I mentioned, computational fluid dynamics, ASEB has worked with NASA for several years. We are very strong supporters of what they have done in this area. We consider CFD totally complementary to the use of windtunnels for design verification of new aircraft designs, and so if the question were asked, has NASA focused too much on this, our answer to that would be no.

It's a new technology, a new way of getting at design criteria, and we think it's essential to get on with it.

In 1983, we did a special report for NASA and the Air Force—where we pointed out the great needs for both adequate windtunnels and adequate computational of fluid dynamics.

Now when you talk about hypersonics or something like the Aero-Space Plane, CFD is about the only way to go, because you can't build windtunnels to test many of the parameters that apply to those airplanes.

To go back to the facilities question which I mentioned, there are many tunnels that need repair. We've had some tunnels that have actually gone out of service because they're in such bad shape.

We have asked NASA, if they would, to conduct an inventory of the windtunnels which they have and which the Air Force has and compare those to what they see as their needs for the next few years. And they have asked us in return to keep track of this inventory investigation that's going on and advise them as it goes along.

As was pointed out by the other group, we've been spending somewhere in the 1 to 2 percent fraction of the total windtunnel investment per year to try to keep them in shape, and this is nowhere near enough. We say a 5 percent figure would make more sense.

Another special point, air safety, last year about this time, we held a seminar, where we included the Administrator of the FAA, the head of the Flight Safety Foundation, and United Airlines' Vice President for Flight Safety and so on—and investigated, what is going on with respect to air safety and what more needs to be done. It was our conclusion that there was a good working relationship between the FAA and NASA in this area, which is an essential ingredient, but that they need to beef up the efforts on a number of things, and we singled out windshear detection, cockpit instrumentation, pilot and controller errors, and ice removal as some areas that deserved special attention.

With respect to windshear, ASEB has, in cooperation with another Academy group, done a report just a few years ago on how we need a better basic understanding of what goes on in windshear. We need to pay more attention to warning devices that could be either on the ground or in the air, which would help us avoid these accidents due to windshear, and stressing the need for pilot training.

I think it's encouraging that both the FAA and NASA have picked up on this and seem to be doing quite a bit of work.

It's a fact, I think, that 75 percent or so of the accidents that happen are related to human error, either in the cockpit or on the ground in the control system, and so we are stressing a need for more effort by NASA in the human factors area.

At first blush, it looks like they're spending about $26 million. It turns out that only about $7 million of that is going to what we would normally consider human factors, and the rest is going to flight simulation work which, while it's very valuable, does not deal with what you would think would be included under human factors.

Mr. McCurdy. Would that apply to the FAA also? You think they could be doing more?

Dr. McLucas. Definitely, although I have not looked specifically at the FAA's budget.

And we say that in the human factors area, in addition to the areas they're already working, that NASA ought to be doing work on the technology of flight simulators to make more realistic flight simulators and on crew fatigue.

We have a few comments on civil aviation. NASA needs to give strong support to all classes of civil aviation, whether it's large transports, general aviation, rotor craft, or medium-sized such as the commuters.

Now some of the factors that we say need attention are aircraft safety, human factors, low-speed aero-dynamics, drag reduction, fuel efficiency. All these would be of great value to general aviation as they operate in their very strong competitive environment.

Our last point had to do with university relationships. We, in 1985, with NASA, recommended that they increase the support of independent research, another point that was mentioned by the previous group. Universities are likely to be doing research, you know, which is self-generated, innovative, and highly important for future developments.

NASA has responded to a number of our suggestions, such as establishing a point of contact in NASA for university activities. They are doing better coordination with the Department of Defense and the National Science Foundation, but we think there is still room for improvement there.

We recommended the setting up of fellowships at the Ph.D. level and a general buildup of university programs where NASA has had a very good success in the past.

In summary, ASEB has been working with NASA for 20 years. We've had a very good, cooperative relationship with them, and by and large it's been sort of a mutually reinforcing kind of a relationship, where we make suggestions, they pick up on them and vice-versa.

But I think the real concern that we have is, in the last ten years, the environment we face externally has changed. And so the good job that NASA was doing in the past is not good enough now. We think the foreign challenge is such that if we want to remain competitive, NASA has to beef up their overall R&D program, and that includes the basic areas that I expressed earlier, those special areas that I mentioned, with particular accent on not letting those wind tunnels get in worse shape. So they've got to do quite a much better job on the refurbishment of their windtunnel facilities.

But I guess our principal thrust, then, is, we've done pretty well in the past, but we're going to have run like mad to stay up with the competition in the future.

Thank you.

Mr. McCurdy. Thank you, Dr. McLucas, for a very good statement.

Dr. Krone?

Dr. Krone. We appreciate the opportunity to come and express our views also. And let me just say that hearing the previous two groups and the previous two speakers, as a preliminary statement, I will say that there was absolutely no coordination between what I'm going to say and what they said, although I heard an awful lot of very similar comments. In that regard, I will try to be brief and not dwell on some of the things that have already been said.

The AIAA is basically a technical organization, comprised of something over 40,000 members from government industry as well as academia, and being a technical organization, we are naturally oriented toward future capabilities of aircraft.

We think that fundamental to our competitive position in the future are those capabilities, and key to those capabilities are the technology programs that are going on toward them very similar to what Mr. Album said. We are very keenly aware of trends, and I'm not going to go through a number of statistics that show the trend, but I will point out, I think, one that's kind of important. I picked one, in other words, from a number of trends.

The balance of payments (aeronautical products) last year was $10.6 billion, roughly, in our favor on a rather dismal subject. So that's good. It was down 14 percent over the year from the previous year, and if you'll look at that one step further—and I think this is really the key to the important part—is that exports were roughly the same; as a matter of fact, they were slightly higher, 3 percent higher. In other words, we're doing pretty well, selling airplanes overseas.

The down trend was caused by imports, which means, if you want to interpret it this way, they (foreign competitors) are able to compete better for our market. In other words, their performance is coming up, their efficiencies are coming up, and they are getting into what used to be dominated totally by ourselves.

So that's one kind of a trend that we have looked at and are disturbed by.

On the military side, I won't go into any details there either, but the military performance of say the MIG-31 is purported to be as good or better than some of our current aircraft. So there's another trend.

Now the question is really; is it possible to reverse the trend? And we think the answer is yes, if there are large gains in performance to be had through an improved technology in future aircraft.

Now we, AIAA, has recommended over the last few years increases in the NASA budget—in other words, increased level. The feeling that our aeronautical technology programs needed strengthening has sort of reached a critical point. As a matter of fact, the

AIAA formed a workshop specifically to look at what could be recommended, and that's in addition to the committee that I'm representing for AIAA here today.

So the workshop met in November, and there were a number of recommendations which I won't go into right now, but I'll say that these recommendations can be made available to the group.

The main recommendation coming out of it was, as we heard here already today, is that an increase in the technology programs is essential and I will say a little more about that in a second, but also a number of institutional improvements could be made that would increase the incentives and viability of those programs, not directly related to the bucks put into them. Things like the contracting for technology, we buy technology programs under the government contracting scheme, much like we buy equipment or, for want of a better way of putting it, soap. We are actually buying innovative ideas and the contracting methods, and regulation should be according to that product.

The philosophy regarding the wind tunnel—I'll say more about wind tunnels in just a second, but relative to the institutional aspects of it, the Air Force tunnels, the military tunnels basically go by a principle of "who can afford to use them," and what programs can afford to get into them; and the NASA tunnels are basically constrained by the funds that are allocated to them. In other words, they can only run so much of the time. Incidentally, as a sideline, the computer facilities run 24 hours a day, generally speaking. They don't look at the tunnels the same way, because of the funding constraints.

Restrictions relative to publishing of materials. This one is not a NASA problem, but basically a restriction on other than classified subjects for basic research.

Rules governing international cooperation and the government support of the interaction between industry and universities are other areas that have been addressed by the workshop. Just for an example of a few.

Turning to the NASA budget itself, we think that the—again the 7 percent or $375 million that are going into the R&D or the $679 million going into all of aeronautics is insufficient to meet the challenge of these trends that seem to be going in the wrong direction. We do think NASA does a good job, but their resources are spread too thin.

Let me give you an example, just to kind of show you why that's true.

In the '50s and '60s, flight control systems consisted of essentially wires, pulleys, belts, cranks, and simple force field mechanisms, and servos that connected the pilot controls to the surfaces of the aircraft.

Now the future airplanes, to say nothing of the current ones, are essentially a mind-boggling set of multiplexing buses, multiple computers, millions of lines of code, which will include artificial intelligence to help the pilot cope with the high performance as well as the environment that is out there in those kinds of airplanes.

Now the point is, if you have a relatively stable budget going through a number of years, like NASA has, what you buy in the terms of improvement becomes less and less, even if you're keeping up with inflation. It just costs a heck of a lot more to improve those systems because of the nature of the complexity of the technology.

Now if you talk about flight demonstrations, we think flight demonstrations are also extremely important. NASA has quite a few ongoing right now. They also, because of the complexity of the systems, have become more and more expensive, so they buy less, even if those dollars are increased according to inflation.

Now relative to the OSTP goals, the three principal goals of supersonic, hypersonic and subsonic; we support the Aero Space Plane program, basically for the exploration of hypersonic technology. That was an area that was kind of ignored for about 10 years. We think there certainly could be a lot more done in the supersonic area, particularly in regards to an advanced supersonic transport. The problem there was about 15 years ago or so, we kind of took a beating in the supersonic transport area and, as a matter of fact, the cancellation of that program was probably a well advised action.

We think the technology has advanced, however, to the point where the market—especially the market to the Pacific Basin from the West Coast—represents a very potentially viable economic objective, and problems relative to the high investment which relates back to the technology again, the high investments in an advanced supersonic airplane is a big inhibiting factor, and the government really has to take some sort of a role there to make that happen, and NASA should be, I think, a logical and key organization to do that.

Relative to the technology programs themselves, we have heard about them.

Structures and materials. I will just say a word about that as an example again. The increase in the temperature capability in a turbine engine is a very large magnifying factor.

As an example of that, and the materials necessary to get those temperatures up. As an example of that, if you go back a few years, like 20 or 30 years, to the old cruise missiles, high altitude supersonic cruise missiles like the Navajo, the Navajo itself weighed something on the order of 290,000 pounds. You could build a cruise missile today for—with the current technology that would not exactly be the same, but with range and comparable payloads, something like 12,000 or 15,000 pounds. So, it's an enormous multiplying benefit we get out of those kinds of technology programs.

Fluid flow. Let me say one thing about fluid flow prediction and verification. We definitely support the verification side of that. We think that NASA, and rightfully so, has increased their NAS programs. But one thing we could say is if you talk about flow around an arbitrary body with bumps and lumps and so forth, and you also have vortices present in that, you have viscous flow, you have laminar and turbulent boundary layers, imbedded shocks, unsteady conditions over a large range of mach numbers—I will say that you would be—it would be a very risky situation to design a vehicle and spend a lot of money on a vehicle if you didn't have verification of that design by either wind tunnel or some kind of flight program-flight test program. So it's really important.

We totally endorse the comments made earlier about the facilities at NASA. I won't take any more time. We think that's probably—if the NASA budget for aeronautics could be increased next year, we would recommend a very viable area to do that would be in the updating, refurbishment and building of new facilities. In other words, a start to doing that. If nothing else could be done because of budget constraints, that would probably be the one that we would recommend going into.

Flight demonstration programs. They are needed for a number of different reasons. I really won't go into them, but they're critical to technology programs. You've got to focus the technology programs and make them happen, and make them—and create a confidence level that's necessary to go into full scale development programs. You've got to have that—those technologies out of the lab, out of the wind tunnel, and into real flight conditions where they can be integrated with the other requirements that are on the aircraft.

In conclusion, I'd like to say that we appreciate this opportunity. The aeronautics—we believe the aeronautics is critical to the security and the economic well being of the country. There's a worldwide market of over $500 billion out there over the next 10 years or so, and in order to capture our share of it, I think we are going to have to make the right kinds of investments. We think they will pay off, they're not like—you know, it's not like money that's gone forever. We're going to get it back if we spend it, and therefore we strongly recommend increasing the NASA funding for '88, and we think it just makes good business sense.

Mr. McCurdy. Thank you, Dr. Krone and Mr. McLucas.

I have basically three questions. One deals with the general concern about balance of payments and how we turn the dollars the best way on our investment today in aviation and keeping our market share, which has been roughly some 80 percent, I think, in civil aviation.

Do you believe that—you said our competition is getting better, and I agree with that.

Is there a combination—is there a better coordination of government and private industry, or is it a private effort alone? Why do you think that they are becoming that much more competitive?

Either gentleman?

Dr. McLucas. Well, I'll take a shot at it. First of all, much of the technology which is flowing back into this country is technology that flowed out of this country.

I was talking to the head of Air Bus Industries recently, and I guess my first question to him was: Are you one of us or one of them? The head of the American effort here selling out planes in the U.S.

He said, "I'm one of us." And I said, "How do you justify that,"and he said, "Well, did you ever notice that the American content of those airplanes that is coming in here is 50 percent, including the GE engines that are on them."

That's not a particularly good answer, but it's part of the answer.

I think another thing that has facilitated the sale of such airplanes is the terms and conditions. This is an exaggeration, I guess, but Pan Am was provided the free use of Air Bus airplanes until the factory could turn out the models that they wanted. So that was a great incentive to them to buy those airplanes.

Your question about, is it private or is it government, well most of these companies are owned by foreign governments, including the ones that supply the Air Bus and a number of other airplanes that come in. They are the result of a government decision in those countries that aviation is an important industry for them to get into, and they get into them, and then they look at the market and decide how to price the airplanes, and they price them in such a way that they can achieve market penetration.

I have nothing bad to say about any of those airplanes. Every one of them that I've looked at is an excellent airplane. But they decided to go for broke to get some of the American market, and they're getting it.

Mr. McCurdy. Well, the Japanese, of course, have MITI, and they coordinate their research and development and their manufacturing and marketing pretty well, which really leads me to my second question.

Dr. Krone, you mentioned turbine components and the need for development in the materials sector. The Air Force has roughly $125 million this year budgeted for R&D in the ceramics area for engine parts and just general development. NASA has, in the aeronautics, no budgeting, but there is a $10 million figure stuck in there somewhere in general materials.

My concern has been that the military tends to have greater latitude on their R&D dollars, and therefore a greater percentage of the overall budget, and I question whether that is an appropriate amount of coordination from the Government.

Dr. McLucas is a former Secretary of the Air Force. I'd like to hear from him also whether or not there is appropriate interface and coordination on items of great significance to our economy and our future competitiveness.

Dr. Krone. Well, I'll make a comment on the first part, I guess, and maybe a very mild comment on the second part of that question.

Relative to the amounts of money that are—total amount of money that is being put into the research in this area, one of the three that we recommended in the written statement, technologies that could have the most leverage, it goes back to a question of—we're not talking—we don't look at it from—or shouldn't be looking at it from an absolute point of view. In other words, if you say, "This much money is being put in or this much," the question is: What are the opportunities for advancement? How many materials are there, for example?

If you look at the NASA materials budget, which we have, I almost challenge anyone to think of a material that's not being worked on that's in there. So there are lots of materials being worked on, and there are a lot of other materials that there's an opportunity to expand the performance levels of those engines and the structural capabilities in the high-temperature area also.

So from the standpoint of, is there enough—or why do we recommend more when there already appears to be considerable—we don't argue with the point that there is a considerable effort here—the consensus of the workshop, as well as the—our workshop, as well as our committee on this subject, which I chair both of, incidentally—was that despite that, there are many areas—there are areas and there are materials and structural concepts that are really being funded at an anemic level, and it gets into the priorities and who thinks this is more important than this.

That was the general consensus in that regard.

I will make one comment relative to the coordination. There is coordination. The AACB, the Aeronautics and Astronautics Coordinating Board, which I was with on a previous job—I was essentially the Director of Air Vehicle Technology at the Advanced Research Projects Agency, and I was on that Board. NASA is on it, as well as all DOD agencies. So there is coordination going on.

The situation basically is that you still have judgments being made by each of the organizations, and generally speaking, it's like, I think, much like the Congress. It's a, you know—you support mine, and I'll support your circumstance, but it's all—it's all for a good purpose. It's all aimed at trying to get the best overall programs that we can.

Dr. McLucas?

Dr. McLucas. Well, I think the best coordination takes place between people of good will, those who want to see the coordination take place.

During my time with the Air Force, I remember that one of our deputies came to NASA and started doing for NASA what he had done for us, and he eventually became the Acting Administrator, Allen Lovelace.

But I think we don't have to worry too much about money going to the Air Force and therefore not supporting NASA's objectives. On the other hand, I would say that if you want to sit at a table and bargain with someone else about how you're going to expend your resources and how your programs will support his, you don't want to have too small a pile of chips in front of you. And I think that's the position that NASA is in very frequently in dealing with the Air Force.

Mr. McCurdy. The last point I wanted to make, and maybe it's just a statement, if you disagree with me, but I—each of you and Mr. Album, our previous witness, and Dr. McCormick—mentioned the need for major construction, rehabilitation of the windtunnels and facilities.

How in the world did it get to this state? I mean, why is it—why did it take this long to recognize this? We've gotten to the point almost of a critical mass, and all of a sudden, in the worst budget year we'll probably face, is the year that we probably need to put the largest amount into.

Why couldn't we have phased it in over a period of time? Was there no coordination at NASA on this? Or was it just lack of priority? What is your impression?

Dr. McLucas. Well, my impression is, it is question of priority, and it's a question of the squeaking wheel. We noticed recently that some of the facilities are breaking down, and we found major cracks in some windtunnels. When you see things like that, you say, "Hey, I haven't been paying adequate attention."

So I think it's a fault of all of us that we didn't do more earlier. But, you know, the aeronautics field is not the only one where we're finding our infrastructure is falling apart. You hear the same comments on the highways and in a number of other areas.

And so I think we have to say "mea culpa" on that.

Dr. KRONE. Well, I'll make one other comment on that. There were, for example, the National Transonic Facility at Langley was built over the last few years, and that was taking a lot of the funds and resources that were going into windtunnels in general, as well as the problem with the 40-by-80 at Ames.

But I agree, it's a situation like someone driving an older car, and they have budget problems, and they are looking to see how they can just drive that car a little further while they use their resources for some other—for some other need, and then sooner or later, you reach a point where you say, "The car is just not going to serve my needs, so now I've got to go out and buy a new car."

I mean, really, I—my personal opinion, my opinion is it's been that kind of a situation.

Mr. MCCURDY. Well, I don't argue too much, except that we're talking about a fleet of automobiles here, using your analogy. It's not just one or two. We're talking about windtunnels and requirements for enhancement of facilities that are 56 years old, 42. Most of them are older than this chairman—and the ranking member, too, I might add.

[Laughter.]

Mr. MCCURDY. At least a couple of them, I'm sure.

Mr. LEWIS. I've already tipped my hand.

[Laughter.]

Mr. MCCURDY. But, you know, we're talking about reaching a critical mass all of a sudden, and, you know, Dr. Colladay has indicated that he wants—that he's initiated a study and trying to analyze how we got into this situation. But again, in our worst budget year, we're going to be faced with an incredible problem that's going to impinge on other priorities, and we're not going to be able to do the basic research, if we have to pump, you know, $100, $200 million into windtunnel enhancement and facilities enhancement.

That's a major problem, and I wish we had a little longer-range planning and understanding and forecasting in predicting these kinds of problems. A little preventive medicine here now and then would certainly go a long way.

The gentleman from Florida, Mr. Lewis?

Mr. LEWIS. Thank you, Mr. Chairman.

I'm only going to take a couple of minutes. I did notice, as well as the chairman, that the Advisory Committees were recommending windtunnel rehabilitation or reconstruction or what have you, and I think a lot of this has come about over the past couple of years, speaking about the Aero-Space Plane, certainly, and recognizing the regions that we're going to have to move with flight testing in order to make a determination of whether we can continue forward or not.

You had recommended very strongly that this be done, both of you, and one of the other Advisory Committees recommended a $55 million increase in certain areas.

I would wonder if you had any recommendations in areas where we would hold the line this year to last year's spending or this year's fiscal spending for next year in some of the work that NASA is doing and apply any increases into rehabilitation or refurbishment or reconstruction of windtunnel applications?

Would you make any recommendations in that way, or just take the safe route and say, "It should be done?"

How about you, Dr. McLucas?

Dr. McLucas. I don't believe that our group has done the work necessary to answer your question, and I don't want to ad lib on it.

Mr. Lewis. I see.

Dr. Krone. I feel much the same way, with the one comment that as Mr. Album said, we wrestled with a lot of these questions of, do we want to recommend this reduction or this maintaining the line on this program and raising this one.

And frankly, the situation has gotten to a point where I don't think it's advisable to look at it that way. I mean, it's just—almost every technology area that we look at has been anemic in some way over the last five years, with the exception of this hypersonics area, the Aero-Space Plane, which we believe, and I can positively say, is now being funded at a level that's adequate, and we're not recommending any increase there.

But across the board in the key areas now—I mean, if you went into the sublevels, you could probably go in and pick out in the materials area, for example, if we had time to do the study, to go in and find some possible programs where you'd rather have it over here than the way it is, just because there are differences in everyone's opinion.

But other than that, I can't—I can't comment any further for the AIAA.

Mr. Lewis. Well, where we are today is that we're pretty much stymied as far as doing any advanced research whatsoever. And in the past—and I know when I was back in this business—that any project that we had or program that we had, increased cost for windtunnel application would be folded into the cost of the program in order—but that was only a stopgap measure for a particular thing.

It would seem to me that we should be looking at a major effort in this area in order to come up with windtunnel application.

Now this is different than my discussion with Dr. McLucas—or Doctor—the gentleman that was——

Mr. McCurdy. McCormick.

Mr. Lewis. McCormick and with Mr. Album, because we're outside of the realm of general aviation. I think we're looking into areas that are very important to our own national defense and security, that we possibly should be spending money in these areas in order to meet this, and I know sometimes they're trying to sell a pie-in-the-sky, and for people like the chairman and I to try to sell these sort of things, we need certainly some strong recommendations and assistance from people like yourselves and the previous body, so that you can come up with some recommendations that we can use in our arguments and discussions in order to try to assist in this area.

Dr. Krone. Yes, sir. We'd be most happy to assist in any way we can. As far as our workshop that we conducted, we have some specific recommendations there. I have kind of highlighted—highlighted them here, but any further actions or further assistance, we'd be most pleased to provide you with.

Mr. **Lewis**. Thank you. Thank you, Dr. McLucas. Thank you, Mr. Chairman.

Mr. **McCurdy**. I thank the gentleman.

Again, gentlemen, we appreciate your efforts and the work that you've done in your testimony. Your full statements are, of course, included in the record, and again, thank you for your efforts.

[The prepared statements of Dr. McLucas and Dr. Krone follow:]

TESTIMONY BEFORE THE
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

by

DR. JOHN L. McLUCAS
AERONAUTICS AND SPACE ENGINEERING BOARD
NATIONAL RESEARCH COUNCIL
March 11, 1987

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you today as a representative of the National Research Council's Aeronautics and Space Engineering Board in response to your invitation to present the Board's views on NASA's Fiscal Year 1988 aeronautics program plan. Dr. James Kramer, Chairman, and Dr. Robert Korkegi, Director, of the Aeronautics and Space Engineering Board appear with me.

Mr. Chairman, the gist of the Board's comments will pertain to our concern that the nation maintain a balanced aeronautics R&T program to serve our own domestic needs and to maintain our competitive posture in world markets.

First, I would like to give you some background on the Aeronautics and Space Engineering Board (ASEB). It was formed under the National Academies of Sciences and Engineering in 1967 for the purpose of "recommending to government agencies the priorities that should be assigned to engineering objectives, proposing ways of bringing engineering talents to bear on aerospace problems of national importance, and suggesting methods to improve engineering education in the aerospace field."

The Aeronautics and Space Engineering Board numbers twenty-two leading experts from academia and the industry representing key areas not only in aeronautics but also in space activities. They include several members of the National Academies.

Over the twenty years of its existence, the ASEB has provided advice to, and carried out studies for, such government agencies as the Federal Aviation Administration, the Nuclear Regulatory Commission, and the United States Air Force as well as the National Aeronautics and Space Administration.

The ASEB reviews NASA's aeronautics program and projections at least twice a year and has provided long-term, broad programmatic guidance and advice to NASA. For example, on January 31, 1986, the Board reviewed NASA's program plan toward meeting the national aeronautics R&D goals and on April 1 and June 26, 1986, the Board reviewed NASA's FY 1988 preliminary planning issues and initiatives. The Board looks primarily at general technical areas rather than the detail of the program, and focuses on the development of those technical areas needed to achieve specific goals.

In recent years the ASEB has undertaken a number of studies related to aeronautics research and technology for NASA including NASA's Role in Aeronautics, 1981, with individual volumes on Military Aviation, Transport Aircraft, General Aviation, Rotorcraft, and Aeronautical Research; Aeronautics Technology Possibilities for 2000, 1984, which stressed the importance of R&T in aerodynamics, propulsion, structures, materials, guidance, navigation, and control, computer and information technology, human factors, and systems integration--this study was briefed to this Subcommittee at its hearings on March 5, 1985; and Aeronautical Technology 2000: A Projection of Advanced Vehicle Concepts, 1985, which built upon the 1984 study. The National Academy of Engineering itself issued The Competitive Status of the U.S. Civil Aviation Manufacturing Industry in 1985. This study, done in the 1983 and 1984 time period, addressed the changing posture of civil aircraft activity and pointed to the need for a strong U.S. aeronautics R&T program encompassing both civil and military activity if the U.S. is to maintain a strong competitive posture in world aircraft markets.

The ASEB endorses a strong aeronautics R&T program to preserve "the role of the United States as a leader in aeronautical and space science and technology..." as called for in the 1958 Aeronautics and Space Act. As this Committee is well aware, the world picture of aviation has changed over the past five to ten years. Strong competition has emerged in various classes of aircraft. The United States has been the world leader in civil aviation; this has been one of the few industries which traditionally has created a positive balance of payments for the U.S. In recent years, for a number of reasons including direct and indirect subsidy from foreign governments, U.S. civil aviation has suffered from imports eroding the domestic supremacy that the U.S. has enjoyed.

NASA's FY 1988 budget submission reflects our view of a program in the national interest; however, the overall effort in aeronautics should be increased if our industry is to remain competitive in world markets. In examining the long-term budget projections, we are also concerned that there is no expectation for growth beyond inflation.

As I mentioned earlier, it is important for the aeronautics industry that NASA maintain a solid, balanced generic technology program. At this time we would like to comment specifically on the following broad areas of the Board's continuing interest: aeropropulsion, aircraft drag reduction, aerospace materials, and the value of computational fluid dynamics. We would then like to discuss some subjects we believe need special emphasis such as facilities refurbishment, air safety programs, the special needs of general aviation, and NASA's relationship with universities.

Regarding aeropropulsion, funding is at a relatively low level following completion of NASA's vigorous and multifaceted activity in advanced turboprops of various types. NASA management recognizes the need for increased activity in this area in order to have a balanced program that serves the aeronautics community.

However, the ASEB has not reviewed a detailed program plan in this area. We recommend that the Department of Defense, representatives from industry, and the university community be encouraged to take part in an effort to focus on a new NASA aeropropulsion activity which affected parties can support wholeheartedly.

In the area of aircraft drag reduction, the Board believes that hybrid laminar flow technology (part laminar flow control and part natural laminar flow), offers the potential for significant improvements in cruise efficiency. However, the risks associated with practical application are still high, and it is unlikely industry will undertake development alone. The Board commends NASA upon its innovative work to reduce turbulent drag, and recommends that NASA proceed with a large-scale flight demonstration of a hybrid laminar flow system with the continued involvement and cooperative efforts of industry.

Regarding aerospace materials, the ASEB has no disagreement with regard to NASA's decision to cancel its large composite-wing program. Review of the program indicated to the Board that the effort was expensive, too closely tied to a specific design, and not likely to expand significantly the research and technology data base. However, the Board now sees an opportunity to augment the R&T effort in composites to remove technical barriers to their application. In view of this, ASEB conducted a study to identify problems and technology needs and to recommend action on a national plan. This study has been completed and a report is under preparation. Without going into detail, the report will note the potential value of composites for various classes of aircraft, related technology development needs, and the kind of work appropriate for government support (NASA, DoD, and FAA) to build the technology base pertinent to fuller application of composites to aircraft structures.

The ASEB has encouraged the development of computational fluid dynamics (CFD) as an important complement to wind tunnel facilities for design verification of new aerospace vehicles. A few years ago, ASEB conducted a major study[1] under joint NASA/USAF support that strongly indicated the complementary role of CFD and wind tunnel facilities. In fact, the development of hypersonic vehicles will be heavily dependent on numerical analysis because of our inability to simulate all the important parameters of hypersonic flow experimentally in wind tunnels. A more recent study[2] points to technical areas which require particular emphasis in the future development of CFD for external aerodynamics, hypersonics, propulsion, and turbulence. ASEB is pleased to see the progress made by NASA in the development of the Numerical Aerodynamic Simulation Facility as a world-class capability in computational aerodynamics, and believes that NASA's investment in this area is necessary and appropriate.

Regarding aerodynamic facilities, many existing NASA wind tunnels are in need of refurbishment and repair. As a first step to correct this situation, the ASEB has urged NASA to prepare an inventory of NASA and DoD's facilities and their condition and to compare their capabilities with the needs of currently envisioned programs. NASA has initiated this study, and has requested that the ASEB conduct a follow-up evaluation. Funding of refurbishment and repair of facilities has been at a level of about 1% of facility value for many years. It is generally agreed that funding for this purpose should be at the rate of about 5%.

---

[1] "The Influence of Computational Fluid Dynamics on Experimental Aerospace Facilities: A Fifteen Year Projection," National Academy Press, 1983.

[2] "Current Capabilities and Future Directions in Computational Fluid Dynamics," National Academy Press, 1986.

The lead time required to refurbish and modernize old facilities is long--it may take three years or more just to build certain replacement parts. The construction of a new facility would take considerably longer. In view of these long lead times, NASA should pay special attention to projecting its long-term research program to better insure the timely availability of facilities to meet these future research needs.

The ASEB has been concerned about the adequacy of R&D in support of air safety issues and, in the Spring of last year, organized a Round Table with several notable experts in the field including FAA Administrator Donald Engen, the President of the Flight Safety Foundation, and United Airlines' Vice President for Flight Safety.

ASEB was encouraged by the apparent spirit of cooperation between FAA and NASA, but recommended strengthening programs in several areas:

- wind shear detection,
- cockpit instrumentation,
- pilot and air traffic control error reduction, and
- ice removal.

With regard to wind shear, a recent report,[3] issued by ASEB jointly with the Atmospheric Sciences and Climate Board of the National

---

[3] "Low Altitude Wind Shear and Its Hazard to Aviation," National Academy Press, 1983.

Research Council, made several strong recommendations for work in such areas as understanding the physical phenomena, airport warning devices, and pilot training. We are pleased to note that NASA and FAA are moving to implement such recommendations.

According to data presented to ASEB at its Safety Round Table, 70-80% of accidents are due to human error--either cockpit or air traffic control. An ASEB study of aircrew-vehicle system integration[4] found that the 1982 program lacked an adequate data base on human-automation interfaces and that analytical methodology was needed to identify basic causes for human error in order to design for safety and reliability. These are still areas of concern, yet of the $26 M which appears under the heading "Human Factors" in the FY 1988 budget, only about $7 M is devoted to human factors research and technology. Much of the other funding supports the excellent flight simulation facility at NASA Ames Research Center, which is devoted largely to guidance and navigation development and aircraft stability, rather than human factors research.

The basic human factors work is under-funded and not consistent with the high priority placed on aviation safety and cooperative FAA/NASA research. The reduction of human factors funds into targeted programs has resulted in the termination of two areas in which we believe NASA should provide leadership: technology for flight simulators, and research on crew schedules and fatigue. Training equipment and methodology and the innovative use of computer-driven cockpit displays also deserve more emphasis.

---

[4] "Aircrew-Vehicle System Integration: An Evaluation of NASA's Program in Human Research," National Academy Press, 1982.

The ASEB has long believed that civil aviation, including commercial air transport, regional and commuter airlines, general aviation, and commercial rotorcraft, should receive strong R&T support from NASA. Aircraft safety and human factors issues are of prime importance to this sector along with low speed aerodynamics, drag reduction, and fuel efficiency. In preserving a balanced program, it is important to maintain strong support for civil aviation.

Last, in 1985, because of concern over higher level training for the next generation of aerospace engineers, ASEB examined NASA-university relationships.[5] ASEB recommended: improved support of independent, long-term basic research, a focal point for university programs at NASA headquarters, coordination with DoD and the National Science Foundation, fellowships and traineeships at the Ph.D. level (with associated funding for faculty and facilities), and encouragement to universities to strengthen their aeronautics programs. The Board believes that NASA has been constructively responsive to these recommendations by establishing this past year a focal point at headquarters for this activity and by expanding and redirecting its grants to encourage independent work. Through these activities, university aeronautics programs will be strengthened. One area of minor concern that remains is the degree of program coordination with DoD and NSF.

---

[5] "NASA/University Relationships in Aero/Space Engineering: A Review of NASA's Program," National Academy Press, 1985.

In summary, for the past twenty years ASEB has regularly reviewed NASA's program in aeronautics and NASA has generally been responsive to the Board's comments.

As you know, the United States' position in aviation has eroded in recent years and therefore one has to look at NASA's role with a more critical eye. We face a new situation today with strong competition in the transport aircraft markets and a need for superiority in military aviation.

While we are in general agreement with the contents of the NASA FY 1988 aeronautics budget submission, we believe that increased support is required just to maintain our competitive status in world markets.

NASA's research in the basic disciplinary areas is the backbone of the nation's technology base and should be strongly supported. We are concerned as well that adequate systems technology studies be conducted in areas with high potential for application. As I mentioned earlier, however, an area requiring immediate attention is the refurbishment and upgrading of national wind tunnel facilities. This investment must be large and will necessarily be spread over several years.

Thank you again for this opportunity to express the views of the Board and for your attention.

Attachment. List of ASEB reports on aeronautics.

AERONAUTICS AND SPACE ENGINEERING BOARD
REPORTS ON AERONAUTICS

1986	Current Capabilities and Future Directions in Computational Fluid Dynamics
1986	Review of Technology Trees for National Aeronautical R&T Goals
1985	Aeronautical Technology 2000: A Projection of Advanced Vehicle Concepts
1985	NASA - University Relationships in Aero/Space Engineering: A Review of NASA's Program
1984	Aeronautics Technology Possibilities for 2000
1983	The Influence of Computational Fluid Dynamics on Experimental Aerospace Facilities: A Fifteen Year Projection
1983	Low-Altitude Wind Shear and Its Hazard to Aviation (A Joint Study with the NRC Atmospheric Sciences and Climate Board)
1982	Aircrew-Vehicle System Integration: An Evaluation of NASA's Program in Human Factors Research
1982	Aviation Turbine Fuels: An Assessment of Alternatives
1980	NASA's Aeronautics Program: Systems Technology and Experimental Programs
1980	National Transonic Facility: A Review of the Operational Plan
1980	An Evaluation of NASA's Program for Improving Aircraft Fuel Efficiency
1980	NASA's Role in Aeronautics: A Workshop
1979	NASA's Aeronautics Research and Technology Base

Statement to

Subcommittee on Transportation, Aviation and Materials
Committee on Science, Space and Technology
U.S. House of Representatives

by

Dr. Norris J. Krone, Chairman
AIAA Advisory Committee on National Aeronautics

American Institute of Aeronautics and Astronautics

March 11, 1987

TESTIMONY

The Status of National Aeronautics

The American Institute of Aeronautics and Astronautics is a professional technical institute with over 40,000 members working through the country's industries, universities, and numerous government agencies. As a technical organization we are naturally oriented towards the future capabilities of our aerospace products which have as their foundation the current technology development activities. The competitiveness of tomorrow's commercial products in world markets and the superiority of the future military aircraft are directly related to the level of support given to "today's" aeronautical technology efforts.

Consequently, we are very aware of trends that provide us with indicators of how well we are doing in the technology race (and it is a race) relative to the rest of the world. These trends and indications can then be used to judge the adequacy of our current technology programs. This judgment is directly dependent upon an evaluation of the strength of the competition and the opportunities for improvement.

Our message today can be characterized by one word - concern. The concern is that relative to the competition, the trend of our worldwide leadership in aeronautics is in a downward direction and it has a downward slope of significant magnitude. There are clear indicators that support this position. For example, aeronautical products have been a very bright spot in the dismal balance of trade picture for a number of years but the brightness is fading. In 1986 the balance was approximately 10.9 billion in our favor; however, it represented a 14% drop from the previous year. The drop was not caused by a reduction of our aircraft exports (actually increased by about 3%) but by a huge increase in imports which went from approximately $4.5 billion in 1985 to $6.1 billion in 1986.

Likewise, indicators of our military aeronautics position are found in comparisons of the relative performance of our aircraft to foreign designs. Here again the trends are downward. The Russian MIG-31 Foxhound is reported to be superior to any existing U.S. fighter aircraft.

With these and other similar indications, it is our position that the country's current aeronautical technology development programs are not adequate. The question then becomes, is there an opportunity to reverse the situation and create a positive trend in our worldwide position in aeronautics? We believe the answer to this question is a definite yes. This belief is based on the potential large gains in aircraft performance that are possible through the integration of advancements in a number of technology areas. These have been highlighted in recent reports such as one by the National Research Foundation.[1] Also, national goals have been established and documented by the President's Office of Science and Technology Policy (OSTP). Despite the significant importance of defining these critical technologies and goals, however there remains a need to define meaningful activities for implementing them and for eliminating the institutional impediments that restrain the efforts to achieve the goals.

The AIAA conducted an aeronautical workshop in late 1986 for the purpose of focusing attention and energy on reversing the adverse trend in aeronautics by focusing support on specific implementation actions. The most important of the recommendations calls for increased funding investments in support of specific technology programs that can lead to superior aircraft performance (both military and commercial) and increase future sales. In recent years foreign governments have been furnishing more and more direct support to their aircraft industry. This includes direct funding for specific aircraft development as well as for technology development programs. In addition, these governments either own the industry or support consolidation practices that would violate current anti-trust statutes in the U.S. We must increase our funding levels accordingly.

---

[1] "Aeronautics Technology Possibilities for 2000: Report of a Workshop," Aeronautics and Space Engineering Board Commission on Engineering and Technical Systems, National Research Council, National Academy Press, Washington, DC 1984.

Also, there are a number of important institutional impediments that should be eliminated or reduced in severity in order to assure our continued position of worldwide leadership in aeronautics. These include the entire area of federal contracting which should be amended to address the special circumstances surrounding the "buying" of technology: the philosophy which governs the use and support of government wind tunnels and other facilities (and limits their use), the restriction on publishing the results of basic research data, the philosophy that governs the incentives for strong government and industry interaction with research in the nation's colleges and universities; and the philosophy and rules concerning internal and international cooperation.

NASA FY88 Aeronautics Program

General Level

The FY88 NASA budget allocated for aeronautics is insufficient to conduct an adequate aeronautics program. This judgment is based on our assessment of an overall level required to maintain U.S. world leadership in aeronautics. Of the total $10.6 billion requested for NASA in FY88, $679.0 million (less than 7%) is allocated for aeronautics and of this only $375.0 million is for Research and Development activities.

The reason for the low aeronautics R&D level is not due to its lack of importance but rather to the high (and properly so) priority that is attached to the NASA efforts to maintain the U.S. leadership in space. Under the severe restrictions on increases in the total funding level, the aeronautics programs are forced to continue with inadequate funding.

We believe NASA does a good job of managing the available resources and that they understand the areas of deficiency; however, they are faced with an enormous unsolvable problem under the current funding level. Simply stated, they have too many critically important technical areas to cover and are spread alarmingly thin in each area. As the technology becomes more and more sophisticated, the hardware and software becomes more complex, and the resources needed to make advances increases proportionately. This is true in all of the technology disciplines that make up the aeronautical "technology base." As an example, the flight controls of aircraft in the late 40s and 50s consisted of little more than mechanical systems of cranks, pulleys, springs, wire, and simple force and feel mechanisms that connected the pilot controls to the control surfaces. In sharp contrast, the control system requirements of the next generation aircraft dictate a "mind boggling" level of complexity involving sophisticated multiplexing architectures, numerous redundant computers, and millions of lines of software that include artificial intelligence capabilities to assist the crew in coping with the severe flight environment and high performance requirement of these vehicles. In addition, all aspects of the craft's operation (such as flight control and propulsion systems) must be integrated to work harmoniously together. A similar situation exists for the other disciplines that the NASA R&D program is attempting to cover.

To further complicate this situation, NASA is supporting several large flight demonstration programs such as the X-Wing, the X-29, the advanced turboprop (ATP), and others. We firmly support these activities; however, they have likewise become more complex and expensive which puts an even further strain on the aeronautics budget.

The major point we are making is that in real terms the NASA aeronautics R&D program is being significantly reduced by virtue of maintaining a fairly constant funding level year after year.

Office of Science and Technology Policy Goals

We have reviewed the OSTP aeronautical goals and see the transatmospheric (hypersonic) goal as being pursued with vigor in the form of the National Aerospace Plan program. We strongly support this effort as one that promises great benefits for vehicles in the 21st century, and of equal importance, one that will yield high technology spin-offs in the nearer term. NASA deserves much credit for pursuing, during the 1975 to 1985 time period, the technologies and particularly the scramjet and hydrogen fuel efforts that make this program possible.

The subsonic and supersonic goals are suffering under the present budget constraints. The subsonic aircraft systems are in need of emphasis in the areas of commuter and low disk loading (rotory wing) vehicles, and general improvements in light weight, efficient, small propulsion systems. Substantial work is needed to integrate the most current technologies in the areas of handling and ride qualities, acoustic noise reduction, and vibration reduction. Vehicle design concept trade-off efforts that integrate these and the other basic technical disciplines are areas that NASA should assume a greater leadership role. These efforts can have the effect of significantly decreasing cost and increasing sales of commercial aircraft.

Additional supersonic cruise work is recommended to prepare for an advanced supersonic transport and more efficient supersonic military aircraft. NASA should take the lead in performing integration trade-offs and design studies involving handling/ride qualities, propulsion concepts, acoustic control, integrated engine/flight control, natural laminar flow, safety, and other basic concepts that can reduce the dollar cost and increase the viability of an advance supersonic transport. There does exist a high potential market for this type aircraft - specifically on routes between the U.S. to the Pacific basin.

Technology Base Programs

As a direct result of the low and approximate constant funding levels of spending power for the last five years, all principal areas of the technology base programs are in need of strengthening. We have reviewed the NASA submissions and strongly recommend increased support in these areas:

1. Advanced Materials and Structures.
2. Fluid Flow Prediction and Verification.
3. Controls, Guidance, and Handling Qualities.

Improvements in these areas are important to all classes of vehicles.

Advanced Materials and Structures - There is an immense potential for vehicle performance gains through the use of advanced materials in primary structures and in engine hot sections. As an example, the increase in turbine hot section temperature and lighter structures has made possible an order of magnitude reduction in a long-range cruise missile weight, size, and cost over that possible with the technology levels of a decade ago. The NASA program includes a large variety of work on a large number of materials (advanced metallics, ceramics, polymers, carbon-carbon fiber stiffened composites, aluminide matrix-silicon, carbide components, thermoplastic composites, etc.); and in addition, the development of computational structural mechanics methods to analyze and optimize complex aircraft structures. There is much additional effort needed in the areas of material characterization, fatigue, manufacturing and inspection techniques, and cost reduction. Clearly, the potential benefit dictates the advisability of additional funding of this program area.

Fluid Flow Prediction and Verification - The accurate prediction of flow fields around actual air vehicle exterior configurations or through the propulsion systems - where there exists vortical flow regions, viscous conditions, both laminar and turbulent boundary layers with shock wave actions, a wide variety of mach numbers with unsteady conditions, and under a wide variety of angles of attack - remains an area that requires much effort and large investments. The computational methods are far from perfect. The NASA budget reflects a good appreciation of this situation. However, there remains a shortage of resources to verify the accuracy of the emerging methods and to define their limitations (when they work and when they don't and why). Wind tunnel model and flight testing programs are the principal means for building the necessary confidence in the computational methods and therefore must be expanded by a comprehensive program.

Integrated Controls and Handling Qualities - The control and guidance function is an example of the squeeze in aeronautics in an important area. In addition to classic control and guidance functions, the control architectures for future aircraft will include the use of artificial intelligence and will function to:

1. alleviate wind shear and other static and dynamic loading to extend the vehicle's flight envelop
2. provide assistance during landing and takeoffs
3. optimize the cruise legs through interfaces with ground controllers
4. improve safety by failure detection and reconfigurable techniques
5. improve cruise efficiency by the integration of the propulsion and flight control surfaces.

NASA Research and Development Facilities

We recommend supplemental funding to support a major upgrade of the NASA wind tunnel facilities. For many years this important area has been underfunded. The NASA facilities that support the country's aeronautics R&D efforts are one of the major elements to maintaining a superior aeronautical posture. There exists a need to refurbish existing facilities in order for them to maintain their efficient usability and to examine areas where technology has moved beyond the capability of the existing facilities. The 16 major NASA tunnels for the most part have been operating for over a generation, and are restricted in their use (the 12 ft. tunnel at Ames is an example). There exist critical shortcoming in the ability to conduct systems research simulation in hypersonic aerodynamics, propulsion and high temperature structures. The cost of upgrading these old facilities and the creation of new ones is so high that a national investment is essential.

Technology Demonstration Flight Programs

We recommend supplemental funding (on a yearly basis) dedicated to supporting technology demonstration programs. Flight research is required for the following reasons:

- To demonstrate the integration of a concept or multiple advanced technologies into a flyable vehicle.
- To fill the gap created by ground test facilities which do not adequately cover the entire flight regime of future operational vehicles.
- To act as a focus for research programs and produce confidence in the advanced technologies.
- To accelerate application of high-risk technologies to full-scale operational systems.
- To fill the critical gap between laboratory research and system application.

In summary, there is need for a vigorous pursuit of significant experimental and technology demonstrator flight vehicles in order to provide militarily superior aircraft and economical commercial transportation, thereby retaining the pre-eminence of U.S. aeronautics technology.

Conclusion

The aeronautics industry is of critical importance to the nation's security and economic well-being. The future health of this industry is directly related to the investment we make in today's aeronautical technology programs. With a projection for over 500 billion dollars in worldwide aircraft sales during the next ten years, it is essential that we make the necessary investments in technology development today. These investments in the past have given us our current position of leadership and they will pay large dividends in the future. Based on this, we strongly recommend a strengthening of the NASA aeronautics funding in FY88.

Mr. McCurdy. The next panel will be Mr. Harold Andrews and Mr. William Kovan, Chairmen of the Congressional Aeronautical Advisory Subcommittee on NASA's Aeronautical Advisory Committee and Advice and Assistance to Industry.

Is Mr. Koven not here?

Mr. Andrews. I would like to make Mr. Koven's apologies. He was also assigned to NASA's Committee that is looking at the tunnels and they are out of town this week, so I will be doing the talking.

Mr. McCurdy. That's fine, Mr. Andrews, and we look forward to your testimony. If you have a complete statement it can be admitted into the record; if not, we appreciate a summary of your position and look forward to your statement.

Mr. Andrews. Yes, we would like to have the Summary Report in the record and I am going to summarize the summary, and if I cut it too thin by all that I'm sure you can come back and ask questions.

Mr. McCurdy. That's fine.

STATEMENT OF HAROLD ANDREWS, CHAIRMAN, CONGRESSIONAL AERONAUTICAL ADVISORY SUBCOMMITTEE ON NASA'S AERONAUTICAL ADVISORY COMMITTEE ON ADVICE AND ASSISTANCE TO INDUSTRY

Mr. Andrews. Mr. Chairman, we are very pleased to be here. I feel a little bit like you have all gone to a very elaborate and fine opera and as it has all come to a close and you are about to leave, somebody says, Oh, wait a minute, we want to tell you about how we do this. In other words, I am dealing with a small slice of the problem—not the problem, of the situation—rather than with the grand aspects of the program itself.

However, it is not unimportant, and in view of the criticality of resources, as or which has been pointed out both by yourselves and by other prior speakers, it certainly has some importance as to how effectively some of those resources are utilized.

We are dealing with an independent subcommittee of the Congressional Aeronautical Advisory Committee whose report you heard earlier. We were asked to look at two things: the effectiveness of NASA's Aeronautics Advisory Committee System and the effectiveness of NASA's direct technical advice to industry. The latter doesn't mean how the big programs respond to somebody's ideas of what ought to be done for the future, but how is industry assisted in the problems that come up in applying advanced technology and, for example, in operating problems that somebody may have like the wind shear problems and like the problems of the hydroplaning of some years ago, as well as in the application of technology in the manufacturing companies.

Our advisory subcommittee functioned independently and we are reporting independently of the overall congressional advisory committee. I think you are all aware that the NASA Aeronautics Advisory Committee functions under the NASA Advisory Council. It is one of the committees under that Council, and is the one that deals with aeronautics. And by definition, those are NASA's outside comprehensive advisory committee operations. And they are chartered under a NASA instruction.

Last year during the hearings before this committee and the Congressional Advisory Committee's deliberations, some issues were raised regarding the effectiveness of the operations in the two areas. This led to a decision that these areas didn't logically fall under the Congressional Advisory Committee itself because of their attention on the overall programmatic and budget issues. So at the suggestion of Mr. Album and Representative Brown, your predecessor as Chairman of the subcommittee, asked us to form a subcommittee and to get on with looking at these areas.

We did that; we formed a committee of eight of us, including the two co-chairmen, all of whom have long experience in aeronautics, either in government or industry or with associations, and all of whom except one had been members of the AAC in the past. We were specifically asked not to include members of the current congressional advisory committee and we made our own decision that we would not include members of the current NASA committee but would use people who had enough experience so that we didn't have to have a startup time.

The committee in getting together agreed that we could address the AAC and provide a reasonable report in the time available, since we were formed in late December and it was desired that we be able to report at this time to coordinate with the other reports.

In terms of the advice to industry, we felt that the issue was more complex and we could not really deal with that fully in the time available. However, by adding some questions to the questionnaire that we used to solicit much of our information, we could take an overview look at that situation and the results would indicate whether a more detailed look ought to be made. And we have done that. So we will give you what we feel is a fairly thorough report on the AAC itself, and we give you overview comments and some interesting things that stem from those in connection with the advice to industry.

The committee, over the two months that we have operated, had an initial meeting in which we obviously went through the procedures that we intended to follow, looked at the pertinent basic documents, got briefings from NASA management and the current chairman of the AAC, and reached a decision to send out a questionnaire to current and prior members of the AAC. We used the charter instruction as a basis, not because we expect committees to follow their charters precisely, but you have to be able to have some series of definitions to which you are going to ask questions. And we felt that after we had looked at the charter that it covered all the things that we thought that kind of an organization ought to deal with and that we could use that as a basis for our efforts.

From the initial review, there were two points that came up that are very significant, and I think that this afternoon you are already very much aware of one aspect, and that is that the NASA's Aeronautics Advisory Committee is not their only source of advice and information. We have heard from the ASEB who handled specific questions for them and we have heard not quite in so much detail but there are a number of DOD and service, NASA research coordination groups that deal with giving advice and doing coordination, and of course many others in the FAA and the more commercial side of the industry.

The second thing that we dealt with is the fact that NASA has recently reorganized its AAC operations, and obviously if you are going to look at something in midstream when it is being reorganized, it isn't quite the same thing as looking at it in its form when it's been functioning that way for a number of years. It first started to function in its new organization in April of last year and the initial results from that new form are expected starting in April of this year, so we are dealing with our best judgment of, and the NASA AAC members' best judgment of how some of those things are going to work out.

In a general sort of way, previously the committee consisted and was built around a concept of a number of vehicular and technically-oriented subcommittees, and the heads of these subcommittees became, in effect, the Executive Committee of the AAC. And there were roughly 80 to 100 people involved in the series of subcommittees that constituted that operation.

Now you might say that takes the technology and works up from there. The current organization is an AAC executive committee of some 20-odd people, and under that you have an aeronautical research and technology subcommittee of close to 50 people. They are the specialists who used to populate the individual subcommittees. Now the Executive Committee is, you might say, the primary instrument, and before, the subcommittees were the primary instrument of action.

We put together a survey questionnaire and sent it to 130 current and prior AAC members, many of whom were both—they had been members before and are currently members. We had questions that got numerical or specific responses for tabulation purposes in order to compare things, and we got comments that filled out.

We got 71 timely usable responses, which is not too bad for that kind of a questionnaire. And by and large, most of them were fairly serious—very serious, as defined by the extent to which they went into comments. And these constituted our major source of evaluation data. Now obviously, the eight members of the committee also had their own views and had experience, but data per se came from that.

And as I have indicated before, we added on to the questions that dealt with the AAC, which we had put together initially, a smaller number of questions that dealt with, to a satisfactory extent, the advice to industry.

After getting the survey results back, we met again, got some additional inputs from individuals with experience and went ahead and analyzed the results and came to tentative conclusions and recommendations.

So in a nutshell, that's kind of where we went through.

Mr. McCURDY. Mr. Andrews, we appreciate the detail on the methodology but I think we are going to be having a vote here shortly. I would like to get to the recommendations, and we have those in written form but we want to have your statement on those, if we could.

Mr. ANDREWS. Yes. That's exactly where I am. In the AAC what we were really looking for was: were the right things being done by the right people in the right way? And we have concluded, and the fundamental conclusion was that the AAC is functioning in accordance with it charter and is an effective organization.

The recommendations follow from some things that we feel would enhance the operation, and I will only comment on two or three of the more significant ones; the others are perhaps more of an administrative nature. We believe that NASA and the AAC should take action to ensure that the user needs are more fully identified and reflected in NASA program plans. That stems, if you go back to the rest of the report, from the fact that there is a tendency to focus on NASA's current programmatics and there are several comments that relate to the fact that they ought to look a little bit more long term, look at a little bit more feedback from industry—or feed perhaps forward from industry.

The second thing—and it ties very much to that and to things that have been said earlier today—the AAC should give increased attention to NASA's institutional objectives and other long-term issues. Very good attention is being given to all the programmatics and to achieving program objectives.

Membership terms should be lengthened. We feel that three years is not yet the full benefit from people when it takes you about two years, in that you're not doing this full time, to come up to speed. And so we think that an extension to five or six years as a maximum term, rather than the three years currently in the instruction, would be advisable.

And one of the things that we think is very important is that the current structure meets headquarters' needs. We think that the new structure is going to meet their needs very well. But it loses some of the advantage in the interchange between the more technical members of the committee and the senior people in the NASA laboratory system. And so we think they should structure meetings to enhance that interchange, and we're concerned that that is lost a little bit in the current system.

So those are recommendations in the area of the AAC. In other words, we think basically it is functioning extremely well in terms of meeting headquarters' needs as it has been reconstituted. We think there are some things that can be done to get an even more effective result from that.

Technical assistant to industry, equally quickly, I think that again, the overall conclusion is that NASA is being asked by industry to provide assistance and is providing that assistance. That was indicated by 90 percent of the respondents, which is what we are really going on. So we feel that probably this is not a problem area that needs any further investigation.

However, from that we got into some areas that have been addressed here this afternoon and which we would be merely reinforcing. We are concerned that NASA's emphasis on the large-scale technology validation programs has adversely affected basic research, and I think you have heard that enough times this afternoon. I won't dwell on it.

A question was raised whether NASA has adequate technical expertise in all the areas that it should. We think NASA should take a look at that. We're not sure that they should have technical expertise in every area as opposed to having it in the forefront areas.

We think that they should examine the balance between the support of these large-scale validation programs and their fundamental research, and that has been gone into previously this afternoon before. We obviously weren't looking at that in detail but we think that is a problem area that needs some good looking.

In addition, perhaps you could stretch that one step further and ask whether some of these validation programs could not be done in a more economical fashion. It is sometimes fun to put all these things together with all the bells and whistles, but there may be reasons why you could do it more economically. That is kind of a supplementary output from looking at this area of technical expertise that is available to industry.

So those are probably the most important things that have come out of this. There are other things that are more of an administrative nature, as I've said, and they are in the summary report.

Mr. McCURDY. Thank you very much, Mr. Andrews. We appreciate very much the effort and the time that you spent in looking at this, and certainly drawing upon your experience as an advisor. I think rather than for me to ask a series of questions I think what I am going to do is recommend that the subcommittee direct NASA to provide for us in writing a reaction to the recommendations of the subcommittee, but also the Congressional Aeronautics Advisory Committee to us, and for NASA to respond. Because I think then we will have an opportunity to develop a little dialogue here and perhaps we'll be back with you to get a little more detail on that reaction.

Mr. ANDREWS. Fine, sir, we'll be happy to do that.

Mr. McCURDY. I think you've done a good job and we certainly appreciate that. Mr. Lewis?

Mr. LEWIS. Thank you, Mr. Chairman. I would just like to thank you, Mr. Andrews, and I have no questions at this point, Mr. Chairman. I think your proposal is fine.

Mr. McCURDY. I appreciate that support. We are going to have a very good working relationship on this subcommittee and I certainly look forward to working with Mr. Lewis and having his leadership.

Mr. Andrews, again, thank you. The next subcommittee meeting is Tuesday and we will be marking up NASA, so your views and recommendations are timely. Thank you, sir. We stand adjourned.

[Whereupon, at 4:48 p.m., the subcommittee meeting was adjourned.]

APPENDIX

CONGRESSIONAL AERONAUTICAL
ADVISORY COMMITTEE

REPORT TO CONGRESS

ASSESSMENT OF THE NASA AERONAUTICS PROGRAMS AND BUDGET FOR FY 88

RECOMMENDATIONS

March 11, 1987

Table of Contents

Page

Chairman's Introduction 1

National Air Power and Its Importance 1
The Decline of U. S. Aeronautics 6

Major Findings and Recommendations 8

NASA's Aeronautics Program 10

A. Emphasis on Aeronautics 10
B. Programs and Budgets 12
C. NASA Laboratory Capabilities 18
D. Facilities 19

NASA Budget Assessment 21

Membership

Congressional Aeronautical Advisory Committee
1986-87

Chairman

Mr. H. Harvey Album
H. Harvey Album & Associates
Rancho Palos Verdes, CA

Transports

Dale S. Warren
Director, Design & Technology
Douglas Aircraft Company
McDonnell Douglas Corporation

Mark E. Kirchner
Director, Engineering Technology
Boeing Commercial Airplane Co.

Dallas M. Ryle
Chief Engineer - Research & Technology
Lockheed-Georgia Company

General Aviation

David R. Ellis
Manager, Aerodynamics & Product Research
Cessna Aircraft Company

LeRoy P. LoPresti
Vice President & Chief Engineer
Beech Aircraft Corporation

Helicopters

Edward S. Carter
Chief Scientist
Sikorsky Aircraft

Franklin D. Harris
Deputy - Senior Vice President
Research and Engineering
Bell Helicopter Textron, Inc.

University

Professor Barnes W. McCormick
Department of Aerospace Engineering
The Pennsylvania State University

Professor Robert Stengel
Mechanical & Aerospace Engineering
Princeton University

High Performance Aircraft

Norman N. Lewin
Vice President & Chief Engineer
Grumman Corporation
Aircraft Systems Division

James M. Sinnett
Vice President
Advanced Design Engineering
McDonnell Douglas Corporation

Airlines

Richard J. Linn, Manager
Load Planning System & Noise
American Airlines

Walter J. Overend
General Manager
Programs and Performance
Delta Air Lines, Inc.

Propulsion

Gerald L. Brines
Manager, Advanced Engine Programs
Pratt & Whitney Aircraft Group

Frank E. Pickering
Vice President & General Manager
Group Engineering & Technology Div.
Aircraft Engine Business Group
General Electric Company

Government

John Chuprun, Jr.
Director, Design Analysis (ASD/XRH)
Deputy for Development & Planning
Air Force Systems Command

Russel G. Perkins, Jr.
Director for Systems Alternatives (AIR-52)
Naval Air Systems Command

Richard M. Carlson
Director, U. S. Army Aviation R&T Activity
U. S. Department of the Army
Ames Research Center

Allen R. Atkins II
Director
Aerospace Technology Office
Defense Advanced Research Projects Agency (DARPA)

Neal A. Blake
Deputy Associate Administrator for Engineering
Federal Aviation Administration

Congressional Staff Contact

Winifred Mathis
Staff Assistant
Subcommittee on Transportation, Aviation and Materials
Committee on Science, Space and Technology
U. S. House of Representatives
Washington, D. C. 20515
202/225-9662

CHAIRMAN'S INTRODUCTION

The Congressional Aeronautical Advisory Committee was established in 1984 to advise the Congress on aeronautics in general and on NASA's aeronautics programs in particular. In 1985, the advisory committee recommended 10 specific changes to the submitted FY86 budget, amounting to $20.2 million in increases and 16.1 million in decreases. We recommended cancelling three facilities related programs that required between 100 and 200 NASA personnel annually and would have later cost the government about $300 million for the resulting facilities. Congress acted on some of these recommendations. The following year 1986, we recommended that Congress accept NASA's submitted FY87 budget for aeronautics without change because virtually all of our recommendations from the previous year were included in the FY87 budget. Furthermore, NASA indicated future plans during our review that included movement along the lines we recommended. Congress accepted that submitted FY87 budget without change. These earlier recommendations were made under a self-imposed artificial restraint of trying to provide Congress advice that would not lead to significant budget increases above the submitted levels. This year, the Congressional Aeronautical Advisory Committee realized that it must fully reflect the true situation for aeronautics, regardless of other budgetary pressures. In this report, we advocate major improvements that are absolutely necessary in NASA's organization, its programs, and laboratory capabilities. The committee recommends changes in direction that are relatively modest in bugetary terms, but they will have a profound impact on the pace of future aernautics advancements. It is clear to this committee, after extensive study of the situation, that changes must be made if we hope to turn around this nation's slowed pace and slipping position in aeronautics.

NATIONAL AIR POWER AND ITS IMPORTANCE

The first question before the Congress is: How important is aeronautics? There have been exhaustive studies by the Executive Branch of Government and extensive testimony before Congress in dealing with this question. The great weight of evidence and expert opinion leads to the same conclusion. Aeronautics is enormously important to the economy, the defense and the welfare of the United States.

However, there appears to be a certain lack of understanding and recognition of this fact, particularly at high levels in Government. Perhaps, we as a nation have become so accustomed to being the world's greatest aeronautical power that we have become unaware of its importance to us. Many foreign nations recognize the national benefits that aeronautics has brought the United States. They have clearly set their sights on the great promise and power that aeronautics offers a nation. The problem here in Washington seems to be one of visability, simply because you have so many serious problems and crises to deal with. The errosion of our aeronautical strength has taken place over a period of time and, although it has become very serious, it may not appear to be a crisis. Yet, our nation's aeronautical strength; our overall air power; is extremely important to the United States because it is basic to the foundations of not only our military power, but also to the economy and welfare of our nation.

National air power is a matter of national will and pride. It is the spirit of adventure, prestige and sense of achievement associated with flight. You could see it and feel it in the nation's response to the flight of the Voyager around the world. It is reflected in the reaction to the radical X-29, the first new experimental aircraft in a decade, depicted in publications everywhere. The aviation spirit is evidenced by new airline start-ups in the face of fierce competition and years of airline operating losses. The interest of the American public in aeronautics is evidenced in movie theaters, toys, and on television. The spirit of flight is there in people building their own aircraft, hang gliding, ballooning, and flying ultralight aircraft -- which are about as close to recreating the adventures of the birth of aviation as one can imagine. The desire to attain new achievements in aeronautics exists in our universities, government laboratories and in industry. It is reflected in the entrepreneurial development of new aircraft designs such as those of Rutan, Learfan, Avteck, Omac, Beech and Northrop. The will to strive for the heights is the essence of a nation's strength; a strength we must encourage to the fullest and never slight.

The real strength of our nation's air power, therefore, comes from our people; their capabilities and their aspirations. They are the youngsters who first built model airplanes; perhaps later learn to fly light aircraft; became engineers and scientists; became military pilots; go on to become airline pilots; serve as pilots in the military reserve and operate Civil Reserve Air Fleet airliners in times of national emergency.. They are airline pilots, corporate pilots, flying businessmen, police pilots and all others who fly. There are 710,000 civilian pilots in the United States. Airlines employ 355,000 people in the air and on the ground. There were a total of 410,000 non-pilot personnel working in aeronautics in aviation, i.e. navigators, flight engineers, mechanics, etc. A total of another 830,000 people work in the aircraft industries in the United States. There are 92,000 engineers and scientists engaged in all sectors of aeronautical R&D, from universities to Federal government laboratories. These are the people who make this nation a great aeronautical power.

National air power requires a vast complex of strong interrelated aeronautical capabilities and activities within a nation. Consider one sector, air transportation, from the standpoint of your own observations: people learning to fly, constant overhead traffic of light and large aircraft, crowded air terminals, long lines of aircraft waiting to take off, travel bargains and so forth. In fact, airlines carry about 15% of all inter-city traffic -- and that includes travel by automobile. They carry about 90% of all people traveling by common carrier, excluding local area commuter trains. People made 380 million passenger trips on U.S. scheduled airlines in 1985, about half of which were for business purposes. There were 75 million general aviation flights in the United States, in that year, three quarters of which were for business purposes. What you are seeing is a nation on the move in the air.

Efficient and safe aircraft make it possible for businessmen, from large cities and small towns, to conduct business profitably throughout the nation and across the World. There are 225,000 aircraft in the United States. Air transportation allows the use of worldwide labor pools for products. It provides rapid shipment of equipment and parts to sell and to keep industry moving. The result is the availability of more products at lower costs to the public. Economical rapid air transportation makes it possible for companies to expand and decentralize by operating plants in small cities and towns nationwide. General aviation aircraft, including commuter aircraft, are particularly important to to large numbers of people and businesses in small cities and towns widely spead across America. There are 221,000 general aviation aircraft in this country, over half of which are used for business purposes. The results of business expansion through air travel is more jobs and greater taxes returned to the Federal Government.

Aircraft are used for a wide variety of agricultural and industrial applications such as oil operations, crop dusting, logging, banking, ranching, building, and many others. Helicopters play an important role in many of these applications. There are 7,100 civil helicopters in the United States.

Both helicopters and fixed wing aircraft are used extensively for public health and safety. For example, there are over 1,000 heliports at hospitals throughout the nation, triple the number that existed ten years ago. In fact, we have 4,200 heliports in the United States; double the number of a decade earlier. Aircraft are used for border and sea patrols, police work, firefighting and air rescue.

The quality of life is greatly influenced by aeronautics. Personal flying is important to a substantial number of people. But, economical air travel benefits the entire american public. It makes it possible for family members to relocate for better jobs and remain in contact with their loved ones. Families can enjoy vacations across the nation and abroad. The travel industry is a major industry in this country.

Military air power is a crucial component of national defense. The military services operate about 20,000 aircraft of all types, i.e. from heavy bombers and transports to light helicopters. The Defense Department spends about $30 billion a year for aircraft. In the committee report last year, I noted the great challenges that our nation faces in military aeronautics across the spectum of warfare. But, let's just consider one aspect again at this time to illustrate the relative importances of military air power. Military aircraft provide the capability for rapid mobility and projection of firepower in both conventional and nuclear warfare. Ballistic missiles can be used only once; at the end of civilization. We have heard a great deal about the importance of a system to intercept ballistic missile,i.e. the Strategic Defense Inititive (SDI). But, true Strategic Defense means that there must also be an effective aeronautical defense as well. The Soviet Union has hundreds of bombers capable of delivering nuclear weapons against the United States. Soviet bombers and submarines can also launch long-range, air-breathing, nuclear cruise missiles off our borders penetrating distances of 1500 miles. We need defense against strategic aircraft and submarines, as well as ballistic missiles. This nation's military air power is supported by the underpinnings of our nation's activities and strengths in all sectors of aeronautics. Likewise, much of expenditures for military aeronautical R&D serves to support advances in civil aeronautics.

Our nation's strength in aeronautics is highly dependent upon the economic strength of the aeronautics industry. Similarly, aeronautics is a prime industry in this country and, therefore, provides a significant contribution to the surrounding economy. Air carriers alone produced about $47 billion in revenue in 1985. Air carriers have invested about $30 billion in aircraft. The vast majority of these aircraft are finance by loans, bonds or are leased. In 1985, our aircraft and parts manufacturing industry had sales totaling about $44 Billion. Aeronautical sales are currently the largest single positive contributor to the net balance of trade with foreign nations, exceeding even agriculture. In 1985, the U.S. sold $17.9 billion worth of aircraft, engines and parts to foreign countries, producing a net positive balance of trade of $6.7 billion.

Aeronautics is the highest technology industry, except for space and missiles. New aircraft require the latest advances in aerodynamics, structures,materials, engines, controls, computers, communication and navigational equipment and so on -- all integrated into a single reliable vehicle that must fly daily. In fact, aeronautical R&D programs have provided enormous spin off benefits to other commercial products. For example, electronics companies have profited from computer chips and digital displays which were initially developed for aircraft systems.

Aeronautics is more R&D intensive than any other industry, except space and missiles. There is one engineer or scientist nationally for every four production workers in aeronautics. Furthermore, there in one engineer or scientist for every 10 people employed in this entire industry. The aeronautics industry requires 30% higher ratio of engineers and scientists in the work force than the next closest industry, which is computers. The U.S. aircraft industry requires an annual R&D investment of about 17% of sales. About four percent (4%) of these funds are invested directly by the companies in the industry, themselves, and the rest comes from the Federal Government. The companies' investments in aeronautical R&D roughly match the average for all durable goods industries in the United States in 1985. Can aeronautics conpanies invest substantially more of their own funds in R&D? The answer is that they can not because their profits on sales are about equal to that of all durable goods as a group (roughly 4%). The next closest industry among 14 major groups, that requires similarly large R&D investments is business computers, which invests about 10% of sales of company funds in R&D. This industry earns over twice as much in sales as does the aeronautics industry. Hense, aeronautics is the most R&D intensive industry in the United States and the Government is a major partner in it.

The government has played the dominant role in a partnership with industry to produce aeronautical avancements since the beginning of World War II. The results have been extremely beneficial to the United States. We have retained world leadership in aeronautics until this decade, when that position began to slip due to a greatly increased pace of foreign advancements. While industrial and government leaders have recently been flocking to management seminars, reading books, and making trips to Japan to learn the magic formula for creating high quality Japanese commecial products, we have had the right equation in aeronautics all along. Our formula has been: (1) a long term partnership between government, industry and universities, (2) a fairly good integration of efforts, with each sector doing the work for which it is most suited, (3) a high level of interaction among the sectors and (4) stimulative government investments in research and technology and military investments in its development programs.

THE DECLINE OF U.S. AERONAUTICS

In simplified form, we have considered thus far the elements of U.S. air power, its importance to the nation, the interrelationships of this vast complex of activities, and the formula that has made it all work in the past. We will not delve deeply here into all the events and facts that indicate our position in aeronautics is seriously erroding. Administration studies and earlier testimony to Congress provide ample evidence of this fact. In last last year's report I addressed the serious challenges that this nation must face in all areas of aeronautics. However, some facts are worth mentioning at this time. We all know that U.S. airlines, as a group, have encountered years of operating losses. Over the last five years there has been a flow of strikes, layoffs, bankruptcies, aquisitions and mergers. In just five years from 1980 to 1985, U.S. civil transport production dropped 43%, civil helicopter production was down 73% and general aviation production was down an astounding 88%. The market shares for foreign companies in aeronautics grew rapidly, world-wide, in all areas. Foreign nations have introduced or are developing civil aircraft to compete with almost all aircraft offered by the United States. Foreign companies dominate the light transport market, i.e. commuter aircraft, even in the United States. A top of the line U.S. civil helicopter was discontinued in production, as were all light single engine general aviation aircraft, save those of one small company. Three U.S. general aviation companies have been sold off in recent years and one is now on the block.

The military air power gap is growing very narrow, and in many places we are not ahead. We have recently placed 35 new large intercontinental subsonic bombers in service (B-1B). However, the Soviets have already fielded hundreds of new shorter range intercontintal supersonic bombers and are completing development of a heavy long-range, intercontinental, supersonic, bomber larger than the B-1B. The Soviets have fielded the only air-to-air fighter-helicopter and the heaviest military helicopter in the world. Europe is developing its own next fighter, as is Israel, while our basic existing fighter designs are a decade or more old. We have just begun the development of a new fighter, while the Soviets have introduced three new ones in the last few years.

It is true that we are making advances in aeronautics but the pace is not fast enough or wide enough to retain leadership. One can cite the tilt rotor aircraft, propfan transports, the Advanced Tactical Fighter, the Advanced technology bomber, the LHX helicopter -- but these aircraft will all be years away. The pace of new basic innovations is too slow and not broad enough, because we have not been investing sufficient resources in the high-leveraged front end of the R&D process. The gains over over existing aircraft must be substantial to justify any new aircraft development program. Attempting to achieve such gains through engineering design, without fundamentally new research and technology advancements, leads to highly complex and costly aircraft designs.

We are rapidly losing our lead in aeronautics because we have been carring on business as usual in the face of adverse trends. For without the will to make changes, we can certainly expect the trends of the past to continue and grow worse in the future. In this following report, the Congressional Aeronautical Advisory Committee strongly recommends the beginnings of a turn around in direction.

2. MAJOR FINDINGS AND RECOMMENDATIONS

The Congressional Aeronautical Advisory Committee recommends the following major changes to increase the emphasis on and momentum of NASA's output of aeronautical research and technology. The fundamental problem is a lack of emphasis on aeronautics in NASA and a resultant short fall of needed broad based research on new aeronautic innovations. We recommend seven basic steps to begin a reversal of this nations declining position in aeronautics:

(1) A Deputy Administrator for Aeronautics should be established in NASA, directly under the NASA Administrator. The Deputy Administrator for Aeronautics should be responsible for all aeronautics programs in NASA.

(2) NASA should be requested to realign its organization and/or management processes to provide more emphasis and focus on its aeronautical programs.

(3) The level of the NASA budget for aeronautics is not and has not been responsive to the increasing needs for new basic innovations in U.S. aeronautics. The FY88 budget for aeronautics should be increased this year by a total of $55 million above the submitted level of $685.2 million. The budget for aeronautics should be increased as soon as possible, to provide another $95 million annually. The general level of support for aeronautics should be at least $800 million per year to accelerate U.S aeronautical advances.

(4) The Aeronautical R&D contract budget should be increased by $30 million over the submitted FY88 budget amount. NASA should primarily expand its innovation research by markedly increasing its broad-based small, low cost, applied research projects in the core areas of aeronautics for that purpose. The core areas are: aerodynamics, structures and materials, propulsion, and flight controls. These small "seed" research projects aimed at new fundamental innovations in aircraft components and design concepts should have been increasing over the last five years. But, instead they have been drastically cut due to a grossly inadaquate budget.

(5) The primary areas requiring augmentations in the FY88 NASA programs are general aviation and commuter aircraft, rotorcraft, subsonic transports, and propulsion.

(6) NASA's laboratory capabilities should be expanded by the addition of at least 150 laboratory research staff members; 103 for new small innovative research projects and 48 to increase the output and improve the results of NASA's flight test programs. The total manpower level in aeronautics should be set at 3,167. We recommend a $15 million increase in the RPM budget for that purpose.

(7) For the last ten years, NASA has been reinvesting only between 1-1.5% of the value of its facilities for upgrades, repairs and modernization. The result is that many of these facilities require repair and modification to meet future needs. The advisory committee recommends a reinvestment rate of 3% of the value of the facilities per year or about $80 million for repairs, rehabilitation and modernization. The advisory committeerecommends an increase of $10 million in the FY88 budget for construction of a seriously needed modification to the 4x7 Meter Tunnel at Langly to provide the only facility for noise testing in the U.S. The committee recommends approval of rehabilitation of the Ames 12 Foot Pressure Tunnel when it is submitted as a special supplementary budget item later this year --if its costs are about $55 million or less.

3. NASA'S AERONAUTICS PROGRAM

A. EMPHASIS ON AERONAUTICS

The emphasis on aeronautics must be increased in response to this country's declining strength in national air power. There has been little response to numerous warnings over the last decade and, except for 1977-80, no real increase in NASA funding for aeronautical research and technology. Now it is evident that as a nation, we are rapidly loosing our world technological leadership position in almost every area of aeronautics. We must face the fact that the health of this nation's air power is beginning to fail.

In two prior reports, we expressed serious concerns about the lack of emphasis on aeronautics in NASA; in its primary goals, funding, and organization. We stated that dramatic changes were needed in all three of these areas to put NASA on the right track in aeronautics. There have been some encouraging words in a few NASA planning documents, but there has been no real change in NASA's emphasis or research momentum in aeronautics. Still, we too did not recommended specific congressional actions to reverse these trends.

Now in the face of continual setbacks, we must advise the Congress that it is time to reverse the negative trends in aeronautics. In this report, we recommend a number of fundemental changes to increase NASA's emphasis and research momentum in aeronautics. These improvements may not seem very great to some outside observers, however, the future effects on our aeronautical technology will be substantial, if these changes are properly instituted and sustained.

Deputy Administrator for Aeronautics

The Congressional Aeronautical Advisory Committee recommends the establishment of the position of Deputy Administrator for Aeronautics and an organizational realignment of NASA, to provide greater emphasis and focus on aeronautics in NASA. This position would be directly under the NASA administrator. It is important to have a single authority at the highest level in NASA, whose sole responsibility and interests are devoted to aeronautics. At the present time, the person closest to performing this function is a Director of Aeronautics, who is three levels below the Administrator within the Office of Aeronautics and Space Technology (Fig. 1).

The Deputy Administrator for Aeronautics would be NASA's chief executive officer for aeronautics, under the NASA Administrator. This position must be established to provide:

- High level visability, review, approval and advocacy for aeronautics programs.
- A prime decision maker in aeronautics to whom
- NASA's Aeronautical Advisory Committee would report.
- A central top-level source of aeronautics R&T policy.
- An executive leader within NASA who can provide a national perspective; by interacting directly with top-level leaders in the Administration, industry and Congress.
- An administrative head of all NASA's aeronautics programs.
- A national leader with whom all those engaged in aeronautics can identify and recognize as the head of aeronautics in NASA.
- A source of leadership toward sustained improvements in NASA's aeronautical research capabilities.

The Deputy Administrator's first task should be to study and implement a proper realignment of the organizational processes for the aeronautics program. This should be done with the advise and consultation of NASA's management staff and outside advisors in aeronautics. The prime emphasis should be on strengthening NASA's in-house laboratory capabilities and creating a supportive and stimulating environment for aeronautical research and fundamental technology development.

Organizational Realignment

The advisory committee purposefully is not recommending the exact nature of the realignment, which is properly a NASA function. However, there are some criteria that we believe the realignment should satisfy:

(1) There should be greater emphasis and concentration on aeronautical research and technology within the agency.

(2) The organization and reporting system should be streamline.

(3) Leadership of research and technology programs should be under managers who understand the technical fields.

(4) Program management should be decentralized with decision making on the lowest possible level commenserate with the size of the programs and greatest knowledge to make the decisions. For example, decision on specific small applied research programs toward new aircraft innovations should be made at the senior researcher or branch level.

(5) The direct laboratory research staff working on original new research should be increased. They should have more time to spend on original new research; i.e. there should be a reduction in paperwork associated with contracting and administrative matters.

(6) There should be a greater focus on individual aeronautical research projects and less spreading of a single researcher's time among multiple projects.

(7) Strong inter-agency, university and industry ties should continue, particularly in joint advisory roles, program formulations, and joint projects.

The advisory committee rejected the contention that synergism between space R&T and aeronautics R&T makes the current NASA organizational structure the best possible one. From close observations, the committee beleives that the current organizational structure reduces aeronautics to second or third class status in the agency. There are cataqories of research and technology that appear similar for aircraft and spacecraft, i.e. structures and materials, control systems, human factors, and others. But, there are only slight actual overlaps or synergism involved because there are very great differences in requirements for aircraft and spacecraft. Even the National Aerospace Plane, which is as close to an overlapping aeronautics and space program as currently exists, will provide very little research and technology for aircraft. It is true that space vehicles must also pass though the atmosphere to take off and land. Hence, spacecraft must be designed with certain aeronautical considerations. However, the converse is not true for aircraft in regard to requirements for space flight. The greatest aeronautical problems for spacecraft and the National Aerospace Plane are flight under reentry conditions. Research and technology for these conditions and special spacecraft configurations are of little value to general aviation aircraft, subsonic transports, helicopters, or even supersonic aircraft. The propulsion systems are also totally different. NASA's aeronautics organization can and should continue to support NASA's space programs for their specific needs. The aeronautics resources would remain within the same agency, headed by the NASA Administrator. However, there should be a management chain, from the highest level in NASA, solely dedicated to managing NASA's aeronautics programs and focusing those resources on aeronautical advancements.

B. PROGRAMS AND BUDGETS

Overall Budget

The advisory committee recommends an increase of $55 million above the total FY88 NASA submitted budget for aeronautics. This is the first in the three years of budget reviews that this committee has recommended a significant increase above the submitted budget. The NASA budget for aeronautics is not responsive to the times, and has not been so for a number of years. Greater investments in aeronautical applied research are absolutely necessary now to obtain the high leveraged front end research on innovations that will yield great gains in civil and military aircraft in future years. A step up in investments at this time is justified and must be taken to begin reversing this nation's slipping position in civil and military aeronautics. Aeronautics is too important to this county to let this situation continue.

The NASA budget for aeronautics is not responsive to the greater needs for new aeronautical innovations in the future. The National Aeronautics and Space Administration has submitted a total aeronautics budget of $685 million for FY88. The budget for aeronautics is only 7% of NASA's total budget of $9,481 billion. The NASA aeronautics budget has averaged about $700 million annually, in real terms, over the last 20 years, adjusting for the effects of inflation (i.e. FY87 dollars). The U.S. government increased the NASA investments in aeronautics by an average of roughly $100 million annually above this level during FY77-FY80. This increase coincided with the beginning of accelerating foreign commercial competition in aeronautics and the emergence of very substantial gains in Soviet aircraft capabilities. But, in the following years the Government did not continue to increase or even maintain NASA's level of efforts, in response to greater needs for more innovations and advancements in aeronautics. Instead, NASA's total budget for aeronautical R&T actually was decreased in real terms by an average of about $150 million a year below the 1977-80 level for a period covering the last seven years. The average annual aeronautical budget during this last period was, in fact about $50 million below the average annual budget for the last 20 years.

In our judgement, an increase of $150 million above the current annual budget is needed to reverse the trends and accelerate future aeronautical advancements. Such an increased investment, in real terms, for NASA's aeronautics applied research programs would have an impressive impact on our progress on aeronautlics--even though a change of this amount would appear insignificant relative to NASA's large space budget. As a first step, we recommend an increase of $55 million above the FY88 submitted aeronautics budget, to provide a minimum level of necessary increases in specific areas of research indentified in budget tables in Section 4.

In general, the advisory committee believes that NASA's management for aeronautical programs has been responsive to aeronautical needs and opportunities, in formulating the budget within the given funding level. There have been fine advancements and a number of new technological innovations are emerging from NASA's laboratories. NASA's aeronautical management has attempted to implemeat the great majority of the recommendations made by the Congressional Aeronautical Advisory Committee in earlier years. However, there are serious difficiencies in NASA's aeronautical programs. The cause is the unrealistically low emphasis that the National Aeronautics and Space Administration actually places on aeronautics and on a resultant budget level that has been unresponsive to increased national needs in this area.

Innovation Research

The advisory committee advocates a strong innovation research program. By this we mean laboratory research directly focused on new innovations and concepts for aircraft. These programs would not be aimed at developing prediction methods, as many NASA programs currently do. Most of the increased funds should go to support primarily small, low-cost applied research programs on innovations in the core areas of aeronautics. The core areas are: aerodynamics, propulsion, structures and materials, and flight control. We need an expansion of small-scale experimental and theoretical research efforts on new concepts and components at the high-leveraged front end of the R&D process in these core areas. This is where NASA efforts have been so successful in the past. These small seed research efforts lead to great gain in aeronautics; far beyond the size of their budgets. Yet, they have been greatly reduced due to budgetary pressures, important new large hardware demonstration programs, new facilities programs, movements to other important areas of research, and rising facilities operation costs. Meanwhile, the NASA aeronautics budget has not increased. This has led to a great reduction in small broad-based applied research efforts on new innovations in the core areas of aeronautics.

The facts are that there has been a continual stream of new exciting efforts added to NASA's aeronautics programs. The additions of these worthy efforts and the resulting churning of programs may have given the appearance of a dynamic and an even increasing effort -- at the same or even lower cost. New national problems in aeronautics emerged, such as the crowded air space, and there were new opportunities, such as computational fluid dynamics. NASA has properly added large programs for these efforts as well as for new flight hardware programs, but without increasing the budget or manpower for aeronautics. Something had to give. It was NASA's broad-based, small applied research programs in the core areas of aeronautics. These projects have been diminished seriously. The resources and people left are spread extremely thin in these prime areas.

The applied research and generic technology programs in the core areas provide the genesis of the knowledge, methods, concepts, and innovations that lead to the major advances in aeronautics. However, these programs involve complex theories, experiments, and concepts. The fundamental programs behind these gains simply are not as visible or easy to understand as the large flight hardware programs. In great measure, Congress itself has been responsible for this situation because of a natural inability to recognize the relevance of such basic work. Congress has even directed budget cuts against the "R&T base" to fund large hardware programs, wiping out great numbers of the small seed programs needed for major future advances. NASA realized years ago that it is easier to describe and sell programs in the later stages of the R&D process to the Congress. As a result, there has been less and less emphasis on the fundamental aeronautical research and technology programs in NASA. Yet, these early stages of R&D are where NASA plays its most important role in aeronautics. As a result, fundamental innovations are drying up and advances are comming increasingly from engineering design innovations and at the expense of greater design complexity.

We strongly advocate that the Congress now primarily suppliment NASA's budget for both the research staff and the resources for a substantial number of small applied research efforts directed specifically toward new innovations in the core areas of aeronautics. The NASA laboratory research staff on these small projects should be given a great deal of lattitude to select, investigate and provide useful theoretical results and data for improved aircraft components and related concepts. NASA should encourage radical departures from the past that may yield gains through these programs, but the work should be fundamental applied research, directly associated with specific aircraft innovations. NASA's fundamental innovation research efforts should be increased in steps over the next few years by providing additional increases in NASA's aeronautics budget, specifically for additional research staff and supporting resources for this work. In the program budget augmentations we recommend in Section 4, approximately 80% of the funding and 60% of the additional research staff are for this purpose in the indicated program areas.

Primary Changes For FY88 Budget

The committee's assessment of the FY88 NASA budget submission for aeronautics and our recommendations are present in the tables in Section 4. These tables present our judgements of the importance of NASA's aeronautical programs and recommended changes in those programs for this year. These findings are based upon full committee reviews of NASA's aeronautical programs in visits to Ames, Langley and Lewis research centers, as well as an overall FY88 program and budget review at NASA Headquarters. Furthermore, our assessment this year benefited from the earlier reviews of the NASA programs that this committee conducted during two prior years, as well as from the diverse individual experiences that our committee members have had in their association with NASA and the products of these programs.

The primary changes recommended in the budget in Section 4 are along the following lines:

(1) Broad-based increases for small applied research programs on new innovations in the core areas of aeronautics: aerodynamics, structures and material, propulsion, and flight controls.

(2) Increased support for research in areas where programs are particularly weak in relation to national needs, namely general aviation aircraft, subsonic transports and commuter aircraft, rotorcraft and aircraft engines.

(3) Greater flight test staffing to increase the testing rate and to improve the results from experimental aircraft programs

(4) Special adjustments in other specific program areas based upon the clear need and importance of the work

(5) Greater reinvestments in facilities for specific repairs and modernization

General Aviation

The U.S. production rate for general aviation airplanes of all categories has fallen to about 1500 airplanes per year, less than 10% of what it was six to eight years ago. This has been attributed to many causes, including periods of high interest rates and high fuel costs, rising purchase prices of new aircraft (in part due to high product liability costs), and outdated technology. This dearth of new production and sales has opened the door to foreign competition, even in the small airplane market, which has traditionally been dominated by U.S. aircraft manufactures. Foreign companies already control the commuter aircraft market. At the same time, general aviation and commuter aircraft have a marked impact on rural areas and a vast number of small cities and towns all over America. The military services also require substantial numbers of general aviation aircraft and have also recently been purchasing commuter aircraft.

NASA can help by developing the technology that significantly improves an airplane's performance, cost, utility, and safety. Most general aviation aircraft are basically the result of 30 year old technology. There have not been large enough gains to obsolete these old aircraft designs. Today, newly produced general aviation aircraft must compete with older used aircraft, at half the price. There are insufficient gains in product performance to warrent purchasing new models at much higher prices. It has been said that the general aviation aircraft should be reinvested, starting from scratch.

NASA can supply innovation research that will stimulate a revolution in light aircraft designs. We have recommended applicable budget augmentations for that purpose in: applied aerodynamics, structures and materials, small engines, air traffic control, aircraft safety and flight management systems. For example, flight management techniques can make airplanes attractive to a "new" group of customers who feel that flying airplanes, operating in the present air traffic control environment, and flying on instruments is much too difficult. A totally new approach to flight management can change this perception, making flying safer and reestablishing the general aviation leadership that the U.S.A. is losing.

Subsonic Transports

Our transport manufacturers have been coming under increasing pressures from Airbus Industries. Foreign aircraft manufacturers delivered 13% of the world airliners 1980, which increased to 19% of the last year. The U.S share of the sales dollars involved remained constant at about 87%, but the trends are not good. Even U.S. airlines are beginning to purchase larger numbers of Airbus and other foreign transports. There are many reasons for these trends but they all center around the competitiveness of government backed aircraft companies in technology and sales tactics.

NASA can supply key innovative advances in many areas that will improve the performance, operation, and safety of transports -- and improvements in our air transportation system. We have recommended small augumentations in people and contract funds for the FY88 budget towards these ends for aerodynamics, structures, flight management, safety and propulsion.

Rotorcraft

NASA's rotorcraft program is important because of: (1) the unique dependence of the U.S. Army on NASA for rotorcraft research and facilities, (2) the public service role of rotorcraft, (3) the high degree of impact from the close proximity of rotorcraft operations to the community at large, and (4) the intense foreign competition to U.S. rotorcraft.

NASA budget for rotorcraft has diminished in recent years and there are short falls in a number of areas. We recommend increases in NASA's budget for small applied research projects in aerodynamics and propulsion. In addition, we particularly recommend additional work on power train technology and noise transmission at NASA Lewis.

Finally, with respect to Rotorcraft Systems Technology, the committee has reassessed its prior year position. NASA's aeroacoustic systems technology is now beleived to be continuing in a quite satisfactory manner.

Propulsion

The greatest advances in aeronautics are usually led by improvements in propulsion systems. We have witnessed a contraction of valuable fundamental applied research efforts at NASA Lewis in the areas of fanjet components, fuels, and innovative small concepts. We recommend increases for and expansion of NASA's applied research and technology on components and concepts for: small engine technology, engine hot section, and ultra high bypass turbo fanjet engines for transports.

C. NASA LABORATORY CAPABILITIES

The advisory committee has recommended increases in the NASA budget of $55 million. We recommend that the bulk, or even all, of these funds to be used to increase the capabilities and conduct applied research directly in those laboratories. The research and technology output of these laboratories is a vital element of the equation that has made this nation successful in aeronautics in the past.

We recommend an increase of 150 NASA laboratory research staff members in aeronautics above the FY87 level of 3,217, bringing the total compliment in aeronautics to 3367. The specific areas where these increase are most important may be seen in the tables in Section 4, in the right hand columns. We recommend an additional 103 staff members for small innovation research programs in the core areas of aeronautics and 43 additional flight test staff.

NASA aeronautical laboratories (earlier NACA laboratories) have been known as one of the best applied research laboratories in the world. Unlike many other ventures where the government has attempted to produce innovations for commercial use and failed, the output of NASA in aeronautics has readily found its way into military and commercial applications. The prime element here has been an extremely competent research staff and an environment which fostered creative work and innovation. Concentrating expertise in these government centers of excellence, along with first rate research facilities is the key to much of our progress in aeronautics. Industry will not and cannot provide this level of support or kind of environment for long term innovative research.

D. FACILITIES

NASA must embark upon a repair, rehabilitation and modernization program for its aeronautical facilities. We recommend an annual facility reinvestment rate of at least 3% of the value of these facilities per year. The advisory comittee concurs with the facilities items submitted by NASA for the FY88 budget, but finds this budget grossly insufficient (Section 4). NASA has an extremely important national role in the operation of its large complex of existing aeronautical facilities for in-house laboratory research and for use by industry, the military, and other government agencies. We are alarmed by the deteriorating condition and lack of modernization of NASA's wind tunnel facilities. NASA has many wind tunnels that are in high demand today and which are likely to remain so for the foreseeable future. The total replacement value of NASA's existing facilities is about $2 billion. For over a decade, NASA has been reinvesting only between 1.0-1.5% of the value of these facilities, per year, for repair, maintenance and modernization. Such a reinvestment rate, would imply an average useful life for these facilities of over 75 years. This is clearly a completely unrealistic expectation.

NASA's existing aeronautical facilities are not being properly maintained and modernized. The consequences of inadaquately reinvesting in these facilities are: short falls in needed capabilities, low productivity, large operating costs, breakdowns, critical delays, and safety problems. The NASA administration must face the fact that the national wind tunnel complex, of which they are the trustees, under law, is deteriorating and much of it is slipping into a worsening state of antiquation. Most of NASA's wind tunnels are between 20 and 30 years old and many are even older. For example, there are tunnels at Langley that were built prior to World War II that still have wooden propellers and electric motors with the original windings. Some modifications are just being submitted to correct this situation, for one such tunnel.

Many of the tunnels are developing cracks because they were made out of low quality steel during World War II. For example, the Low Speed 12-Foot Pressure Tunnel at NASA Ames is out of commission and must be completely rehabilitated this year, for this very reason. We recommend that a special supplement for this tunnel be approved later this year. This facility is a unique and important national resource. It is important because of its large test section and flow capabilities which, at reasonable cost, will allow testing aircraft at high angles with a good simulation of full-scale flight. The Ames 12-Foot Tunnel is extremely important for developing the next generation of U.S. civil transports and is also important for almost all other types of aircraft development programs in the U.S. as well. NASA aeronautical facilities must be repaired or rehabilitated as the needs arise, but the NASA funding for this purpose has been far from adequate.

NASA must modernize and expand the capabilities of their aeronautical facilities to meet current needs. For example, U.S. aircraft companies have had to use a wind tunnel in the Netherlands for crucial noise testing, for helicopters and other civil and military aircraft, because we do not have such a wind tunnel in the United States. Anyone who has ever heard a helicopter nearby will realize the importance of being able to develop quiet helicopters and the competitive advantage that would result. The limited access and availability of this foreign wind tunnel is hampering U.S. development efforts and depriving us of innovative research to reduce noise. It is important to U.S. aviation to modify the 4x7 meter tunnel at Langley to provide the United States this crucially needed capability. Timing is important in this regard. Now we must recommend that congress add this item and the necessary funding to NASA's FY88 budget.

The output of NASA's aeronautical facilities is a crucial element in the strength of U.S. aeronautical R&D. These facilities must be used for the small innovation research that we are advocating toward new advancements in the future, as well as for near tearm technology and development programs. Upgrading NASA's facilities is a vital component of the turn-around strategy that we are advocating to get American aeronautics rolling again at a pace faster than that of other nations in the world.

4. NASA BUDGET ASSESSMENT

The following tables contain the Congressional Aeronautical Advisory Committee's assessment of the NASA FY88 budget for aeronautics. The tables contain the committee's recommendations for changes in this budget. Summary tables are presented first, then detailed tables for each catagory are presented. the total aeronautics budget consists of three primary catagories. The first in R&D funds are contract funds. Most of these funds are applied to operate NASA facilities and support in-house laboratory projects. The rest are used to purchase research and technology from other sources. The second catagory is facilities costs, which includes costs of facilities, repairs, rehabilitation and modifications of facilities. The third catagory is Research and Program Management, which are funds to pay NASA personnel 70% and to perform certain center housekeeping functions (not associated with experimental facilities.

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
SUMMARY OF TOTALS				
AERONAUTICS TOTAL BUDGET	685.2	740.2 (+55)		The advisory committee recommends an increase in the FY 88 NASA budget for aeronautics, in spite of the budgetary pressures on Congress this year. This is the first in the three years of budget reviews that this committee has recommended a significant increase above the submitted budget level. Greater investments in aeronautical applied research are absolutely necessary now to obtain the high leveraged front end research on innovations that will yield great gains in civil and military aircraft in future years. A step up in investments at this time are justified and must be taken to reverse this nation's slipping position in civil and military aeronautics. Aeronautics is extremely important to this country, e.g. it provides the greatest positive contribution to this nation's net balance of payments in foreign trade. Aeronautics has an enormous and pervasive impact on the economy, welfare, and defense of this nation. The National Aeronautics and Space Administration has submitted an aeronautics budget that is only 7% of NASA's total budget of $9.481 billion. The NASA aeronautics budget has averaged about $700 million annually in real terms over the last 20 years, adjusting for the effects of inflation (i.e. FY 87 dollars). The U. S. Government increased the NASA investments in aeronautical R&T by an average of roughly $100 million annually above this level during FY77-80. This increase coincided with the

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				beginning of accelerating foreign commercial competition in aeronautics and the emergence of very substantial gains in Soviet aircraft capabilities. But, instead of increasing or maintaining this pace of efforts in response to greater needs for more innovations and advancements in aeronautics, NASA's total budget for aeronautical R&T actually decreased by an average of about $150 million a year below the 1977-80 level for a period covering the last seven years. The average annual aeronautics budget during this last period was, in fact, about $50 million below the average annual budget for the last 20 years. In our judgment, an increase of $150 million is needed to reverse the trends and accelerate future aeronautical advancements. But, to be effective, these funds must go to support primarily small low-cost applied research programs on innovations in the core areas of aeronautics; namely, aerodynamics, propulsion, structures and materials, and flight control. We need an expansion of small scale experimental and theoretical research efforts on new concepts and components at this high leveraged front end of the R&D process in these core areas. This is where NASA efforts have been so successful in the past. These small seed research efforts lead to great gain in aernautics; far beyond the size of their budgets. Yet, they have been greatly reduced due to budgetary pressures, important new large hardware demonstration programs, new facilities programs, movements to other

Priority/Importance 100 - Critical
90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				important areas of research and rising facilities operation costs. The NASA aeronautics budget has not kept pace with the needs; this has led to a great reduction in the small broad-based applied research efforts on new innovations in the core areas of aeronautics. The bulk or even all of the recommended budget increase should be used to improve NASA capabilities to conduct original applied research in NASA laboratories and to maintain and modernize NASA's existing complex of research and testing facilities. An increased investment of $150 million a year, in real terms, for NASA's aeronautics applied research programs would have an impressive impact on our progress on aeronautics -- even though such a change would appear insignificant relative to NASA's large space budget. As a first step, we recommend an increase of $55 million above the FY 88 submitted aeronautics budget to provide a minimum level of necessary increases in specific areas of research identified on the following pages.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
SUMMARY BUDGET BREAKDOWN				
AERONAUTICAL R&D (CONTRACT)	375.0	405.0 (+30)		
RESEARCH & TECHNOLOGY BASE	285.2	311.2		
SYSTEMS TECHNOLOGY PROGRAMS	89.8	93.8		
TOTAL FACILITIES COSTS	36.1	46.1 (+10)		
RESEARCH & PROGRAM MGT.	274.1	289.1 (+15)		We recommend establishment of a total complement of 3367 people devoted to NASA's aeronautics activities as part of the budget process. Our recommendation is based on a need to increase NASA's laboratory research staff by at least 150 over the FY 87 manpower level which was 3217. NASA's submitted FY 88 R&PM budget is actually based on a reduction of 104 people in the aeronautics work force to 32113. These manpower levels do not include NASA's activities specifically devoted to the National Aerospaceplane Program, which is treated as a separate special program.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
BUDGET BREAKDOWN				
AERONAUTICAL R&D (CONTRACTS)				
RESEARCH AND TECHNOLOGY BASE	285.2	311.2 (+26)	80.2 (62-91)	The advisory committee has carefully examined all of the programs being conducted in the Research and Technology Base. We believe that NASA management in aeronautics have essentially done their best to provide R&T programs responsive to the needs of industry and other government agencies and have taken advantage of the new opportunities that have emerged. They made changes consistent with the great majority of our past recommendations to the extent posssible within NASA's given resources for aeronautics programs. The programs in the FY 88 budget are valuable efforts and relatively well balanced within the given level of funds. But there are serious omissions and deficiencies in NASA's aeronautical research programs due to the fact that NASA's budget for the R&T base have not kept pace with the needs. Small applied research programs toward new innovations in the core areas of aeronautics have not been increased. They have been seriously depleted. New, large, more visible programs and facilities, though important, have had an extremely negative impact on these smaller, broad-based applied research programs. The following recommendations reflect the first and most important steps necessary to address this shortfall.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				We recommend an increase of $26M over the submitted budget for the R&D contract portion of the research and technology base programs and an increase of 124 research staff members in NASA laboratories to pursue small applied research programs specifically aimed at achieving advances and concepts for new aeronautical innovations.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
1. Fluid & Thermal Physics	29.0	29.0	83 (73-85)	The committee believes that base programs are very important and we concur with the overall level of this contract budget. However, we recommend an increase in NASA laboratory research staff in this area by 21 above the FY 87 level. The categories requiring increases are discussed below. The individual programs under this budget category have priorities ranging from 73 to 85, with a weighted average of 83. With the support provided by this program, NASA continues to maintain national and world-wide leadership in fluid and thermal physics predictive methods. More importantly, the increased computational capability that is being provided will have a significant impact on the enhancement of current aircraft in the future.
Computational Methods and Applications	7.1	7.1	85	Although funding for computational methods and applications appears modest under this budget category, overall R&D contract funding for computational fluid dynamics is about $69M -- an increase of approximately 60% beginning in 1985. We believe that this level of funding is sufficient; it is 18% of the total R&D contract budget. Funding for operation of the National Aerodynamic Simulator has been transferred for FY 88 from this budget category to System Technology -- with a $2 million increase in the total effort. We concur with these changes.

Priority/Importance 100 - Critical

90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				NASA has increased its efforts on predicting turbulent flows -- which is the key to successfully predicting the complete flow fields and aerodynamics of full scale aircraft. A significant number of gains in predicting aircraft flow fields have recently been made. The results of this NASA program are highly utilized by industry and the military services. These improved predictive methods yield fundamental knowledge about flows and better aircraft designs with less wind tunnel testing. This program provides better predictive methods, which are not in themselves new innovations for aircraft designs. NASA must make use of these tools, as it does wind tunnels, to conduct applied research toward new innovations in aircraft components.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Flow Modeling and Verifications	5.1	5.1	84	We concur with the submitted budget but recommend an increase of three NASA laboratory research staff members above the FY 87 level. Implementation of computational fluid mechanics depends on the ability to create reliable mathematical models that accurately describe the flow about the aircraft. Understanding the flow field through experimental observation is important to help create this model. In addition, the math models must be verified by experiment before they can be used with confidence. This program is focusing on key computational fluid dynamic cases where the reliability of the computations is limited by the ability to accurately model the flow. It is important to expand NASA's laboratory staff in this area. Even just several additional competent researchers can make a great difference in unlocking the mysteries of complex flow phenomena, such as turbulence.
Experimental and Analytical Aerodynamics	8.4	8.4	84	We concur with the submitted contract budget for this area, but recommend an increase of 10 NASA laboratory staff members to conduct small research programs on new innovations for aircraft. As in the current program, these research efforts should make use of wind tunnels, water tunnels, highly advanced test techniques, computational fluid dynamics and other theoretical methods. The current

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				work comparing small scale test data, theoretical predications and flight test data, to verify the use of small scale and theoretical predictions, is important and should continue.
Viscous Flows	4.7	4.7	81	We concur with the NASA submitted contract budget, but recommend an increase of six research staff members above the FY 87 level. Efforts under this program have largely concentrated on laminar flow control and natural laminar flow which have a high potential payoff, if successful. Research is also being conducted to understand other types of flows that can markedly impact the aerodynamics and performance of aircraft. The recommended increase in research staff is to enhance NASA's laboratory capabilities to conduct small research efforts on understanding and utilizing flow mechanisms that can have strong influences on aircraft aerodynamics. These new staff would work on expanding new innovations in aircraft component designs and favorable interactions between the flow fields of aircraft surfaces. The emphasis should be on increased innovative uses of interactive flow fields and on advanced wing designs. Work on transition is highly promising and should be continued.

Priority/Importance 100 - Critical

90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Subsonic Transport/ Commuter/Gen Aviation	2.9	2.9	73	We agree with the contract budget submitted for this area but recommend an increase of two research staff members to increase the flight test rate and documentation of results for laminar flow and other flight test experiments. We recommend continuing the laminar flow control on natural laminar flow experiments. The laminar flow control flight test results imply, for the first time, that it may be practical to apply this mechanism to reduce aircraft drag and, thus, substantially increase aircraft performance. These are highly innovative approaches and could yield great gains. Although these are not small programs, including NASA manpower, they are being conducted using a low cost approach as recommended by our committee last year. The program is risky, the final results are uncertain; but the potential gains are well worth the modest investment. Much of the laminar flow control work is also conducted under the prior category of Viscous Flows.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
2. Applied Aerodynamics	61.	64.	82 (79-86)	Under this very important budget category, aerodynamic theory and practice come together to provide design principles, guidelines, and data for a full range of aeronautical vehicles. The individual programs were given high priority ratings (79-86), and the funding levels were felt to be appropriate, except as noted below.
Subsonic Transport	6.9	8.9 (+2.0)	86	Because of an immediate and important need for fundamental work in the basic configuration aerodynamics of commuter and general aviation aircraft, we recommend that funding for research in these specific areas be increased by $2M. In addition, we recommend an increase of twelve (12) NASA laboratory research staff members for this effort to conduct small research projects to enhance innovations in subsonic commuter, general aviation and transport aircraft. Our reasons are as follows: o Restoration of U. S. preeminence in the design of commuter aircraft. o Aerodynamic technology embodied in current U. S. designs for GA aircraft is several decades old. o Resurgence of GA industry has important implications for domestic economy and transportation system.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				o U. S. industry would benefit from use of NASA experimental and analytical tools for applied aerodynamics.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Rotorcraft	12.4	13.4 (+1.0)	83	Rotorcraft configuration design is a complex problem which is inadequately understood, leading to the recommendation that funding for applied rotorcraft aerodynamics be increased by $1.0M. Even more importantly, we recommend an increase in NASA's laboratory research staff by 14 positions over the FY 87 level to expand NASA's research programs toward innovative solutions to helicopter drag, noise and vibration problems. These recommendations are made for the following reasons: o Foreign competition in helicopter production is increasing rapidly, increasing the importance of maintaining a technological lead. o The continuing drive for reduced helicopter noise and vibration is strongly coupled to vehicle aerodynamics. Recent progress on understanding these phenomena make it timely to initiate rotor configuration studies, looking to possible later demonstration of an efficient low-noise, low-vibration, high-speed rotor. o Generic design data for multi-rotor interference and interaction with fuselage components is needed greatly.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
3. Propulsion and Power R&T	41.0	51.0	81 (73-85)	We recommend an increase of $10 M in the NASA budget and an addition of 23 members of the NASA laboratory research staff above the FY 87 level. NASA's propulsion R&T programs are very important to the nation. In the past, these programs have been extremely well coordinated with the military services and with industry. NASA has pursued needed avenues of propulsion R&T and provided the necessary catalyst to pull together all segments of the development and user industries to ensure technical relevancy and to obtain maximum leverage of their R&T dollars. The overall priority of this item is 81 and the individual programs range from 73 to 85 in priority.
Small Engine Technology	4.3	8.3 (+4.0)	79	The advisory committee recommends the following changes: There should be a $4.0 million augmentation; $2.0 million of which earmarked for rotary engine research. This would bring the total funding for that category of powerplant to $3.7 million. The rotary engine continues to hold promise for better full consumption and lower weight than all other concepts for general aviation applications. The power plant is the most important element in making revolutionary advances in general aviation aircraft. This level of funding is needed if such an engine is to be available in the early 1990's.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				An additional $2.0 million and seven (7) people would allow other expansion of small research projects to explore other opportunities in the small engine concepts including the compound diesel engine.
Rotorcraft	0	2. (+2.0)	73	The NASA Lewis effort in these areas has been virtually eliminated, in spite of a significant unused facility investment already made and repeated identification of the importance of work on helicopter transmissions and propulsion flight control integration. The advisory committee recommends that the very small helicopter propulsion and power work now being book-kept against rotorcraft structures and materials be augmented by the addition of $2 M in R&D contract funds and six members of the NASA laboratory research staff as a rotorcraft item in the propulsion and power portion of the R&T base budget.
Subsonic Cruise Engines	0	4.0 (+4.0)	80	With the conclusion of the Advanced Turboprop Program, NASA will not be addressing innovative subsonic transport propulsion. Ultra High Bypass Ratio Turbofan Engines offer the potential of dramatic fuel burn improvement for medium to long range transports with wing mounted, ducted, turbofans that cruise up to Mach 0.9. An addition of $4.0 M and ten (10) people are recommended to initiate this very important program. The increase in NASA's laboratory research staff should be an augmentation above FY 87 levels to expand NASA small applied research programs in propulsion concepts and components.

Priority/Importance 100 - Critical

90 – Extremely important	70 – Important	50 – Borderline	30 – Minor	10 – Insignificant
80 – Very important	60 – Worthy	40 – Just below entry level	20 – Very minor	0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
4. Materials & Structures R&T	42. (+3.0)	45. (71-90)	80.6 (12)	The committee recommends an increase of $3.0 and twelve (12) NASA laboratory staff members to expand the work on small innovative applied research projects. The overall level and the balance of elements is proper. All of this work is fundamentally important to improved effectivity and efficiency of all types of aircraft systems. The priority at the elements range from 71 to 90 with a weighted average of 80.6.
Computational Structural Mechanics	3.1	4.1 (+1.0)	81	We recommend an increase of $1.0 M and five (5) additional staff members over the FY 87 level for work in this area. This increase is specifically needed to emphasize computer tools for "local" analysis for aircraft design, e.g. laminate design for composite structural elements. Such tools will have basic utility in development at all structural systems. Composites offer the prospects of radically different design concepts that could reduce manufacturing costs as well as aircraft weight. But, improved predictive methods are needed to analyze such departures from classic box and stringer structures of past aircraft designs. Also, the committee recommends restoring the NASA staff to the 1986 level.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Subsonic Transport/ Commuter/Gen. Aviation	1.2	3.2 (+2.0)	81	There should be an increase of $2M in R&D contract funds and seven (7) research staff members for small size applied research projects on new structural design concepts mostly for general aviation and commuter aircraft, but also including transports. Composite structures could provide great reductions in the manufacturing of these subsonic aircraft by innovative design concepts that depart from past conventions. General aviation and commuter aircraft could benefit from advances in structural designs particularly suited to lighter aircraft. The proposed augmentation is not large but it could provide the seeds for a revolution in aircraft design. It is correct to point out that there is already an experimental all-composite business aircraft, the Starship. This is a good beginning, but there have been beginnings before and it is far from the end of the designs that could be forthcoming. The Learfan was also an all composite aircraft but it has so far failed to receive FAA certification. The Windecker GA aircraft of the 1970s was totally made of composites -- but it never reached full scale production. Advances in innovative composite designs could have a marked effect on the future of civil and military subsonic aircraft. They might well make light general aviation aircraft affordable and safer.

Priority/Importance 100 - Critical

90 – Extremely important	70 – Important	50 – Borderline	30 – Minor	10 – Insignificant
80 – Very important	60 – Worthy	40 – Just below entry level	20 – Very minor	0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
5. Information Sciences	26.0	26.0	67	We concur with the submitted budget for these important activities. Although the priority rating appears lower than other elements of the budget, this item is an important and necessary part of NASA's aeronautics program. This budget primarily supports certain computer facilities operations and, to a lesser extent, research on computational methods, processors and computer requirements. We advise against funding shifts from this budget to augment other elements of the budget with higher priority ratings.
6. Controls and Guidance	27.6	36.6	81 (73-90)	Controls and guidance provide the necessary technology to realize major gains in the performance, economy and safety of aircraft operations. In particular, they provide the theoretical and analytical background within which major advances in computation and electronics can be applied to aircraft flight. The committee's vote reflects the concerns that this area is important to very important, with handling qualities requirements individually being considered extremely important (90). At the same time, controls and guidance research can lead to significant improvements in the capacity of the National Air Space System and a resurgence of general aviation as a vital element of the National Transportation System. The committee recommends $3 M funding increases in each of three areas for a total increase of $9 M: handling qualities, application of artificial intelligence to air traffic control, and integrated flight management and display concepts for general aviation and commuter aircraft. The committee also recommends a

Priority/Importance 100 - Critical

90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				staffing increase of 25 in NASA laboratories for these small applied research programs.
Handling Qualities and Control Theory	1.6	4.6 (+3.0)	91	Handling qualities are the measures by which the pilot's ability to stabilize and control an aircraft is judged. The reliability of these criteria and the degree of compliance with them are significant drivers for any aircraft design. Thus, the development of reliable handling qualities criteria represents an important technical contribution to the entire range of aeronautical vehicles. The Handling Qualities and Control Theory Program has an overall priority of 82 (ranging from 91 for Handling Qualities to 73 for Control Theory). Last year, the committee recommended an increase of $one million for handling qualities and control theory research to restore the budget to the FY 86 level of $2.4 M. Because this recommendation was not implemented and because of the high priority placed on handling qualities criteria research, the committee recommends an increase of $3.0 M to the FY 87 budget, for a FY 88 budget of $4.6 M. In addition, we recommend an addition of ten (10) people to the NASA research staff for this work. This budget would support two efforts: 1. Handling qualities criteria development for flight at the extremes of the flight envelope and for highly augmented controls. (The old criteria developed, in large part by NASA, do not apply to such advanced designs).

Priority/Importance 100 - Critical
90 – Extremely important
80 - Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 - Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				2. Development of criteria using simulators and verification of the fidelity of the use of simulators for such criteria development. It should be noted that the submitted budget contains no work of this kind. The advisory committee rejects the contentions that (1) handling qualities are too aircraft specific to develop criteria, or (2) the handling qualities measurements for just the flight aircraft at Dryden will do the whole job. Both contentions are technically incorrect.
Subsonic Transport/ Commuter/Gen Aviation	6.5	12.5	80	A net increase in staffing of 15 people is recommended for the following two items, accompanied by the noted funding increases.
Artificial Intelligence in Air Traffic Control		3.0	82	Major improvements in the ability to handle increasing air traffic while maintaining and advancing the economy and safety of air travel in all weather conditions can be achieved by introducing "artificial intelligence". (Artificial intelligence is the application of computerized decisionmaking to the problem). NASA possesses unique capabilities to perform needed research in this important area.

Priority/Importance 100 - Critical

90 – Extremely important	70 – Important	50 – Borderline	30 – Minor	10 – Insignificant
80 – Very important	60 – Worthy	40 – Just below entry level	20 – Very minor	0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Flight Mgt & Display Concepts for General Aviation/Commuter Aircraft		3.0	83	There is an important need to revitalize the general aviation industry and the safety of small aircraft operations. A "seed" investment in computer-based flight control, guidance, and display technology is viewed by the committee as providing leverage for these advances. "Intelligent" on-board systems will make commuter and GA aircraft more competitive, enhance the transfer of information to the pilot, and make travel by small aircraft a viable option for an increased population of travelers.
7. Human Factors	26.	26.	82 (82-83)	We concur with this proposed research effort which relates human performance to the aeronautical system. This includes terminal collision avoidance systems, human engineering, and crew interface with expert systems (advanced cockpits). These efforts are appropriate for NASA to undertake, and promote air traffic safety. NASA efforts in human factors in aeronautics is a relatively new area of NASA research that has been substantially expanded within the last five years. The crowding of our air space, increasing complexity of aircraft systems, and the need to reduce pilot errors are all reasons for NASA to conduct research in this area. In particular, work in general aviation should be addressed to reduce the high rate of accidents, which will at teh same time reduce invididual and manufacturers insurance rates -- a serious problem in general aviation.

Priority/Importance 100 - Critical

90 – Extremely important	70 – Important	50 – Borderline	30 – Minor	10 – Insignificant
80 – Very important	60 – Worthy	40 – Just below entry level	20 – Very minor	0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
8. Flight Systems	26.1	27.1 (+1.0)	79 (75-81)	We agree with the work planned for this very important program. The budget should be increased by $1.0M and that the NASA laboratory research staff increased by 17 people above the FY 87 level. Work in this area supports coordinated wind tunnel, analytical and flight research investigations, much of which is critical to aviation safety. The advisory committee endorses this effort because the activities lead to a better understanding of flight hazards, e.g. lightening, icing, heavy rain, and develop design criteria and operating techniques for safe operations for all types of aircraft. This program also supports analytical and experimental efforts aimed at developing the technology base for future fighter aircraft having short takeoff and vertical land capability and also fighters with greatly improved maneuverability at very high angles of attack. Rotorcraft and VSTOL flight operations costs and people are included under the budget items as well as some flight tests costs and personnel for high performance aircraft.

Priority/Importance 100 - Critical

90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Subsonic Transport/ Commuter/Gen Aviation	0	1.0 (+1.0)	81	An addition of $1M and two NASA research engineers for a small applied research project to identify techniques for alleviating wake vortex generation on the aircraft and for development of methods for detection and avoidance of the wake vortex hazard. There is evidence to indicate that the design of the latest generation of twin engine transport aircraft has resulted in increased vortex strengths. Solutions to the vortex hazard problem have both safety and airport capacity benefits. This research program would result in development of guidelines for future aircraft designs and for aircraft operation that reduce the wake vortex hazard generated by the aircraft. This should be an internal NASA laboratory applied research program.
Rotorcraft (flight research)			80	The NASA flight research staff on rotorcraft progress should be increased by six (6) members to increase the rate of flight testing and to analyze and document research results more fully and sooner. This increase is recommended with the stipulation that there is no offsetting increase in the size or number of such programs.

Priority/Importance 100 - Critical
90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Fighter & Attack Aircraft (flight research)			75	The advisory committee recommends an increase of nine (9) NASA laboratory research staff members. This increase is similarly recommended to (1) increase the flight test rate on experimental aircraft, (2) more fully analyze and document flight test results, and (3) provide them to users sooner. The stipulation in recommending this increase is that NASA should not undertake more flight programs offsetting this augmentation. The committee is not recommending an increase in these programs.
9. Systems Analysis	6.5	6.5	62	We concur with this program. These are contracted aircraft system studies and applications studies by NASA's own study groups. The committee believes that it is very important for NASA to provide studies from both sources, particularly for civil aircraft (a priority of 79). The importance rating for the contracted studies by aircraft companies is 79. Among these studies are analyses of the feasibility and viability of effective supersonic and hypersonic transports -- and their relative technologies. However, NASA laboratory aircraft design and application studies under this program have not yet reached the level of accomplishment that will be possible in the future. Hence, the overall rating of the work underway was influenced by this factor.

Priority/Importance 100 - Critical
90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
SYSTEMS TEHCNOLOGY PROGRAM	89.8	93.8 (4.0)	78.4 (37-90)	The committee considers the systems technology effort very important. We recommend an increase of $4M as delineated below. The flight programs provide the tests, engineering experience and the showcase for many aeronautical achievements. At the same time, we note that the fly-rate for a given program may be barely more than once per month, while industry, as a rule, plans 5 flights per month in their flight test development operations. Therefore, the committee recommends an increase of 26 people in aeronautical flight operations and support personnel for the purpose of increasing the basic flat rate, providing assistance and improved timeliness of data reduction, programs documentation, and providing an overall improvement in program efficiency. This recommendation is made with the stipulation that there be no offsetting major increases in the size or number of flight research programs.

Priority/Importance 100 - Critical
90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
10. Rotorcraft Systems Technology	5.0	5.0	69 (37-80)	We concur with the overall level of this budget. Individual programs under this budget item have priorities in the range of 37-80. The weighted average priority for all of the work under this category is 69; but they must be examined individually.
Advanced Rotorcraft Tech.	5.0	5.0	80	Rotorcraft noise is the largest deterrent to the expansion of civil helicopter use and is becoming very important to the U.S. military -- both from a community annoyance and a detection point of view. Current military requirements, current ICAB and planned FAA noise regulation all mandate that new noise reduction technology and ICAO noise prediction methods be developed quickly, and be transferred to the U.S. industry. Rotorcraft noise prediction depends on the ability to predict the unsteady pressure distributions which occur on rotor blades during high speed flight and low speed descending flight. Analytical methods have been developed to predict these pressures and must be validated. A data base is being assembled for this purpose from recent wing tunnel tests (DNW in Holland), full scale helicopter tests, and recent two-speed-main rotor tests.

Priority/Importance 100 - Critical
90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Technology for Next Rotorcraft	0	0	37	This project is a joint effort between NASA and DARPA to demonstrate full scale x-wing conversion, from rotary wing flight to fixed wing flight and the reverse. Flight tests will be conducted on the Rotor System Research Aircraft (RSRA) and are now scheduled to begin early CY 87. While no contract funds are requested, this budget item now requires over 20 man years, since NASA manages this project, and greater numbers of people probably will be required for the NASA flight test programs this year. The low priority assigned by the committee reflects the advisory committee's skepticism regarding the practicality of the x-wing concept. The x-wing configuration is extremely complex and some systems studies, performed to date, have shown it to have an extremely limited mission potential when compared to helicopters, tilt rotor and direct lift configurations.

Priority/Importance 100 – Critical
90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 – Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
11. High Performance System Technology	14.6	16.6	75	
High Performance Flight Research	11.0	13.0	76 (73-79)	The advisory committee agrees with this program but recommends a $2 M increase as defined below. This program covers flight research new experimental aircraft and modified existing aircraft to: o Explore the new capabilities and technologies of the X-29; o Investigate greatly expanded boundaries of maneuverability at very high angles of attack using the F-18; o Examine new wing design concepts with the AFTS-111 and F-106; o Conduct research on VSTOL aerodynamics and control using a Harrier; and o Demonstrate a highly integrated digital control scheme for enhancing airframe/engine performance using the F-15. These programs advance basic generic technology for military fighters, a traditional NASA role that has proved fruitful since the early days of World War II.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
F-18 High Angle-of-Attack Flight Research	2.4	4.4 (+2.0)	79	This program addresses research on greatly increased maneuverability for high performance aircraft. The importance of high angle-of-attack (post stall) flight maneuvers and the very limited state of current knowledge of it makes this program very important. The existing modified F-18 aircraft is a useful tool for conducting fundamental flight research on high angle-of-attack flow fields and operating boundaries. The proposed addition of an inflight thrust vectoring capability will substantially increase the utility of this research aircraft to operate at high angles. Additional funds of an undetermined amount will be required next year. We include this program providing these total costs are under $20M, which we think will be the case.
Oblique Wing Technology (* Contingent upon continued Navy support.)	3.6	3.6*	66*	CAAC recommends minimum NASA support for this program if the Navy withdraws its support. Funds allowing only for an orderly contract closure and documentation of the results to date should be spent by NASA in this case.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 – Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
12. Advanced Propulsion Systems Technology	30.5	32.5 (+2.)	82 (76-84)	The advisory committee considers these programs very important. The priorities of the individual programs vary from 76-84, with a weighted average of 82. The program includes: o The Advanced Turboprop Systems Programs (Priority 84); o General Aviation and Commuter Engine Technoloigy (Priority 80); o The Advanced Weight Temperature Engine Material Technology.
Advanced High Temp. Engine Material Tech.	10.0	12.0 (+2.0)	76	We recommend an increase of $2M for turbine engine hot section technology (priority 78). This program actually consists of several small applied research programs to increase the temperature capability, strength and life of components in the engine hot section. This is extremely important to both military and civil applications and will become even more so with the need for efficient supersonic cruise. The military is relying on this basic program to a great extent. About 50 percent of airline engine maintenance costs are related to the engine hot section, which results in about 25 percent of total airline maintenance cost.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				The hot section technology (HOST) program was formerly accounted for under a separate budget line item. There is some concern on our part that the consolidation of work to this program may not result in the necessary emphasis it deserves.
13. Numerical Aerodynamic Simulation	39.7	39.7	80	The advisory committee concurs with this very important program and the FY88 submitted budget. This facility is proving to be a major national asset for computational fluid dynamic calculations. There are strong user ties with the prime NASA centers, universities and industry. Substantial gains are being made in aerodynamic computational capability.

Priority/Importance 100 - Critical

90 – Extremely important	70 – Important	50 – Borderline	30 – Minor	10 – Insignificant
80 – Very important	60 – Worthy	40 – Just below entry level	20 – Very minor	0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
FACILITIES COSTS	36.1	46.1 (+10.0)	80 (78-90)	We concur with the submitted budget items under (1) Cost of Facilities, (2) Rehabilitation and Modification, and (3) Minor Construction, all reflected in this budget. However, we recommend increases to these budgets for more and better maintenance, repair and modernization of NASA 's huge complex of facilities. NASA has aeronautical research and testing facilities with a replacement value of about two billion dollars. Over the last ten years, NASA has only invested from 1.0 to 1.5% of this value in its existing facilities. This rate of reinvestment would imply that the facilities had useful economic lives of 75 to 100 years. Most of NASA's facilities are 20-30 years old. The results of failing to properly maintain and modernize these facilities have resulted in structural failures, long testing delays, inefficient costly operations and safety problems. The advisory committee recommends a reinvestment rate of at least 3% of the value of these facilities per year; i.e. about $80 Million in real terms (FY 87 dollars). NASA's failure to reinvest adequately in its facilities has created a substantial backlog of expenditures required. We recommend increases in the budget this year for extremely important additional specific facilities modifications described after the submitted programs.

Priority/Importance 100 - Critical

90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Submitted Budget Items				
Dryden Integrated Test Facility Construction	10.5	10.5	78	The propulsion, flight control, avionics and other elements of future aeronautical systems are becoming more integrated and interactive through common computer and software interfaces. This Integrated Test Facility provides the means to connect into the aircraft's internal control network to conduct ground qualification, comparability testing and validation of flight critical functions. It will lead to new testing and simulation capabilities and more efficient operations. The committee concurs with the need for this facility and supports the budget submitted.
Modification of Hypersonic Propulsion Facility	3.1	3.1	78	Hypersonics is taking on increased importance for missiles, SDI and the National Aerospaceplane Program. Facilities must be brought back into service and modernized to meet expanded testing needs.
Addition to Research Analysis Center	9.8	9.8	78	This floor space is needed for research laboratory space and equipment.
Modification to Fan/Compressor Research Facility	6.5	6.5	78	This repair is necessary due to cracks found in the fan which could cause a failure in the near future.
Other Repairs and Modifications to Wind Tunnels and Propulsion Facilities	6.2	6.2	78	These are repairs, rehabilitation, modifications, and minor construction items.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 – Nil

Summary Report to Congress

Assessment of

NASA Aeronautics Advisory Committee
and
NASA's Technical Advice to Industry

by

A Designated Subcommittee
of the
Congressional Aeronautical Advisory Committee

before the

Subcommittee on Transportation, Aviation and Materials
Committee on Science, Space, and Technology
U. S. House of Representatives

March 11, 1987

Last year, during the course of testimony to, and deliberations of, the Transportation, Aviation and Materials (TAM) Subcommittee of the House Committee on Science and Technology regarding the FY 1987 NASA Aeronautics Budget, issues were raised with respect to the effectiveness of NASA's Aeronautics Advisory Committee(s) and NASA's direct technical assistance to the U. S. aviation community. The Congressional Aeronautical Advisory Committee (CAAC) considered these to be important issues, but felt that they could not be addressed within the context of the CAAC's basic activities which focused on assessment of the NASA Aeronautics Budget.

With approval by the TAM Subcommittee Chairman, at that time Representative George E. Brown, Jr., a separate Congressional Aeronautical Advisory Subcommittee was established late in December 1986 to address these issues and report in time for the TAM Subcommittee's FY 1988 NASA Aeronautics budget hearings. This Advisory Subcommittee was made up of eight members (Appendix I), all of whom had long experience with NASA and its NACA predecessor, most having served on their technical and advisory committees. None are currently members of either NASA's Aeronautics Advisory Committee or the Congressional Aeronautical Advisory Committee.

The CAAC subcommittee members agreed that a useful assessment of the effectiveness of NASA's Aeronautics Advisory Committee (AAC) and its operations could be completed in the time available. However, the assessment of NASA's direct assistance to industry would be a more complex and time consuming task, and therefore only an overview look would be possible. This would be done by expanding the planned survey questionnaire sent to current and former NASA AAC members to include questions addressing this area. The responses would indicate whether a more thorough assessment is warranted.

Our subcommittee held two, one-day meetings. During the first meeting, we reviewed pertinent NASA documentation, interviewed the NASA Headquarters Director of Aeronautics, and the current Chairman of the NASA AAC, and agreed on our assessment process. A survey questionnaire was then sent to 130 current and former members of the NASA AAC. 79 replies were received; 71 replies containing useable responses were received in sufficient time for use in the assessment. Subsequent to tabulation of the survey results, and discussions among various CAAC subcommittee members, the second one-day meeting was held to analyze these results, hold additional discussions with individuals having direct experience in the NASA/NACA AAC interface, and to reach tentative conclusions and recommendations. To coordinate with the Congressional Aeronautical Advisory Committee's testimony to the House Subcommittee on Transportation, Aviation and Materials, the following summary is provided of our assessment of NASA's AAC and NASA's direct technical assistance to industry.

This summary report was prepared by the CAAC Subcommittee co-chairmen and has been coordinated with all of the subcommittee members. While some members may differ slightly on wording, or the strength of particular wording, all eight concur generally in the conclusions and recommendations as stated.

One aspect of NASA's AAC operations which must be recognized is that NASA had taken steps to revise the AAC's organization and procedures, with these changes going into effect in April of last year. Generally, the current AAC consists of an executive committee (22 members) which is fully responsible for conducting AAC activities and an Aerospace Research and Technology Subcommittee of 47 specialists in the various technical and vehicle disciplines who can be assigned to ad-hoc AAC task groups or interact with basic disciplinary NASA technical activities. The prior AAC centered on informal technical and vehicle oriented subcommittees with the Chairmen of these subcommittees making up most of the AAC's executive committee, with a total of 80-100 AAC members.

Our survey questions were framed to recognize this action, and the survey results, as well as our conclusions and recommendations take this action into account. Unless specifically noted in the following section on the effectiveness of NASA's AAC, the statements apply both before and since these recent changes were made in AAC organization and operation.

NASA's Aeronautics Advisory Committee

The answers of the 71 current and former members of the AAC who responded to the survey questionnaire were compiled and analyzed. The results drawn from this analysis are covered below. These results, inputs from interviews, and the experience of the subcommittee members were then used to reach the conclusions and recommendations which follow the survey results.

Survey Results:

From 70% to 90% of the respondents viewed the AAC's activities as satisfactory with respect to NASA's program objectives, program balance and allocations, policies and strategies, achievement of objectives and interagency coordination. However, almost one-half felt AAC activities with regard to NASA's institutional objectives were not satisfactory.

The clear consensus (68% to 95% for different aspects) was that all of the operating processes of the AAC were satisfactory, and that the recent changes in AAC organization will be beneficial.

Essentially unanimous agreement existed that:
Qualifications of AAC members were excellent;
Representation balance was excellent.

Less than one-half the respondents considered that industry needs were adequately defined through the AAC most of the time, and just half that these were reflected in NASA program plans through AAC action.

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
Additional Recommended Items				
Quiet 4x7 Addition	0	0 ($10.M)	85	The advisory committee identified the need for an acoustically treated wind tunnel for model noise test of rotorcraft, turboprops and transport aircraft. Such tests must currently be conducted in the DNW tunnel in the Netherlands. Acoustic testing is critical to efforts to develop quieter civil aircraft and to reduce detectability to of military helicopters. We indicated the need for the facilities in 1985 and 1986 but this is the first time we have recommended that Congress place it in the budget. A proposed program to add acoustic treatment to the Langley 4x7M tunnel appears to be the only affordable solution and we have been advised that a $10M program has been fully developed and is ready to start. We recommend that this program begin without loss of additional time.
Ames 12' Low-Speed Tunnel	0	0	90	The approximate cost of this facility is $54 million over three years. We recommend that special A&E funding be provided to initiate work on tihs project this year. This would be a special funding request from NASA when the project is fully planned and firm costs are available.

Priority/Importance 100 - Critical

90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
RESEARCH & PROGRAM MGT.	274.1	289.1 (+15.)	90	We recommend an increase of 150 laboratory research staff members in aeronautics above the FY 87 level of 3217. This would bring the total complement in aeronautics to 3367. The recommended funding adjustment would provide for this increae plus the 103 staff members that NASA intended to transfer out of aeronautics this year. The planned decrease shows the lack of emphasis in NASA on its aeronautics program -- which must be reversed. The staffing levels do not include the National Aerospaceplane Program which is treated as a special program category. NASA aeronautical laboratories (earlier NACA laboratories) have been known as being among the best and most successful research laboratories in the world. The primary outputs of these laboratories has been applied research in aeronautics. This is early front end work on new innovations and concepts that have later been used in the design of civil and military aircraft. Unlike many other ventures where the government has attempted to produce innovations for commercial use -- in aeronautics this has been a formula that has worked for over 75 years. The prime element in this equation has been the extremely competent research staff and the environment which fostered creative work and innovation. Concentrating expertise in these government centers of excellence along with first rate research facilities is the key to our progress. Industry will not and cannot provide this level of support or environment, even through contracts.

Priority/Importance 100 - Critical

90 — Extremely important
80 — Very important
70 — Important
60 — Worthy
50 — Borderline
40 — Just below entry level
30 — Minor
20 — Very minor
10 — Insignificant
0 — Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				Today, NASA's staff devoted to small applied research programs on broad-based aeronautical innovations in the core areas of aeronautics is greatly diminished and thinly spread.

Priority/Importance 100 - Critical
90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
NATIONAL AEROSPACEPLANE				The committee strongly advises that any added research and development work in support of the National Aerospaceplane program should be justified in its own right and supported with a budget and apart from the NASA aeronautics budget. o The aerospaceplane is a highly specialized vehicle. The primary R&D required for it has little in common with research and technology advances vitally needed by the primary segments of aeronautics in: civil and military transports, naval patrol aircraft, fighters and attack aircraft, helicopters, general aviation aircraft, and related propulsion systems. o The Aerospaceplane would kill a large number of smaller important aeronautics R&T programs if this very large program is included in the NASA aeronautics budget without additional funds. The overall affect on aeronautical advances would be very serious. The National Aerospaceplane itself was not assessed by the Congressional Aeronautical Advisory Committee because: o Insufficient information is available to this committee on NASA's detailed plans in relationship to the DoD's research and develoment plans.

Priority/Importance 100 - Critical

90 – Extremely important
80 – Very important
70 – Important
60 – Worthy
50 – Borderline
40 – Just below entry level
30 – Minor
20 – Very minor
10 – Insignificant
0 - Nil

NASA AERONAUTICS BUDGET FOR FY88

CONGRESSIONAL AERONAUTICAL ADVISORY COMMITTEE ASSESSMENT

BUDGET ITEM	SUBMITTED BUDGET ESTIMATE ($ Millions)	RECOMMENDED ($ Millions)	PRIORITY ASSESSMENT	RECOMMENDATIONS, RATIONALE, AND COMMENTS
				o Much of the information needed to evaluate the joint NASA/DoD program in this area is classified and, therefore, unavailable to the entire advisory committee. o The majority of knowledgeable advisory committee members on this topic must disqualify themselves from the evaluation because their companies are bidding on or have contracts impacted by the National Aerospaceplane program funding.

Priority/Importance 100 - Critical
90 - Extremely important
80 - Very important
70 - Important
60 - Worthy
50 - Borderline
40 - Just below entry level
30 - Minor
20 - Very minor
10 - Insignificant
0 - Nil

Almost one-half considered the AAC membership term too short.

Substantial minority views (some 30%) held that:
NASA controlled the meeting agenda;
There were not enough committee meetings.

Strong views were expressed that the changes in AAC organization and operation would inhibit the type and extent of technical interchange between AAC/ARTS members and NASA Center senior technical specialists, which the CAAC subcommittee believes is necessary for effective advice on NASA technical activities.

Conclusions:

AAC is functioning in accordance with its charter and is an effective NASA activity.

Recent changes to the AAC structure and operations should be beneficial to the AAC addressing overall NASA Headquarters programmatic issues, but are expected to inhibit the valuable technical interchange between AAC/Aerospace Research and Technology Subcommittee (ARTS) members and NASA Center senior technical staff.

The AAC does not always adequately define user needs for inclusion in NASA's program.

NASA's program objectives and programs receive major attention by the AAC. Institutional objectives and other overall long-term issues receive significantly less attention.

Term of AAC membership is too short for best use of individual member's expertise.

There is a lack of common understanding among AAC members with respect to AAC objectives and functions.

One meeting per year for the ARTS is insufficient to perform a significant function.

There is a perception on the part of some AAC members that NASA management is not really interested in obtaining objective AAC advice.

Recommendations:

1. Action should be taken by NASA and the AAC to ensure that user needs are more fully identified and reflected in NASA program plans.
2. NASA should clearly define and periodically review for committee members the objectives and role of the AAC and its Aerospace Research and Technology Subcommittee (ARTS).
3. The AAC should give increased attention to NASA's institutional objectives and other overall long-term issues.
4. Maximum membership terms should be lengthened to 5 or 6 years.
5. ARTs meetings should be more frequent -- twice a year is the minimum for effective technical interchange.
6. NASA and the AAC should structure AAC/ARTS meetings so as to encourage and enhance technical interchange between AAC/ARTS members and NASA Center senior technical staff.
7. NASA should take action to dispel impressions that it is not truly seeking AAC advice.

NASA's Direct Technical Assistance to Industry

Only an overview look at NASA's direct technical assistance to the U.S. aviation manufacturing and operating industry was taken, due to the limited time available. A survey supplement went to the current and former AAC members and, with the exception of some academic and government members, the respondents all covered these questions as well as those relating to the AAC.

Survey results:

NASA's direct technical assistance is frequently requested by industry.

Technical assistance is just as frequently provided.

Industry has some concerns regarding protection of its proprietary interests if NASA assistance is obtained.

Priorities/funding sometimes limit NASA's assistance.

A significant minority of those responding (1/3) felt there are some areas where NASA lacks technical expertise.

In relation to NASA's expertise, widely different opinions were expressed on the value of NASA's funding of large-scale technical validation programs as compared to fundamental/basic aeronautical research.

Conclusion:

Overall, NASA direct technical assistance is being provided to meet aviation community needs.

Considerable concern exists, which our subcommittee shares, that NASA's emphasis on large-scale technology validation programs has adversely affected its basic research.

Recommendations:

1. NASA should address the extent to which in-house technical expertise should be maintained in all areas of aeronautics.
2. NASA should examine the balance between support of large-scale technology validation projects and fundamental research to be sure that it is in line with meeting national needs in advancing aeronautical technology.
3. NASA take appropriate action to assure industry that its proprietary interests will be recognized when technical assistance is provided.

Appendix I

Members
Congressional Aeronautical Advisory Subcommittee
on
NASA's Aeronautics Advisory Committee
and
NASA's Advice to Industry

Harold Andrews*
Aeronautics Consultant
Arlington, VA

Richard L. Ballard
Associate Division Chief
Office of Deputy Chief of Staff for Research, Development & Acquisition
U. S. Department of the Army

James L. Decker
Aerospace Consultant
Potomac, MD

Coleman D. Donaldson
President, Aeronautical Research Associates of Princeton (ret);
Consultant

John H. Enders
President, Flight Safety Foundation
Arlington, VA

William Koven*
President, KLD Associates
Aeronautics Consultants
Annandale, VA

Raymond M. Standahar
Propulsion Consultant
Alexandria, VA

Captain J. D. Smith
V.P. Flight Safety/Industry Affairs
United Airlines (retired);
Consultant
Scottsdale, AZ

---

* CAAC Subcommittee Co-Chairmen

Statement of the Air Transport Association
Before the Subcommittee on Transportation, Aviation and Materials, Committee on Science and Technology, House of Representatives
Regarding the NASA Aeronautics FY 1988 Aeronautical Research and Technology Authorization
March 10, 1987.

ATA member airlines today account fcr 93 percent of U.S. airline passenger travel and 97 percent of scheduled freight ton miles. A record 415 million passengers were carried in 1986 and the FAA forecasts further growth to about 600 million passengers per year by 1990.

The airlines place top priority on enhancing the airline safety record. We strongly believe that NASA should continue and expand coordinated research with the FAA to implement near term enhancements in safety-of-flight, the capacity and efficiency of the national airport and airspace system and certification of new technology resulting from NASA transport aircraft research. We also foresee a strong NASA role in implementing the eight action items announced in the February, 1987 report by the Office of Science and Technology Policy (OSTP); "Agenda for Achievement, National Aeronautical R&D Goals."

On behalf of the ATA member carriers who are also end users of NASA research, ATA welcomes the opportunity to submit the following comments on the NASA FY 1988 Aeronautics authorization. Our comments will cover three main areas: aviation safety, NASA's role in supporting modernization of the National Airspace System and research for future transport aircraft development.

Coordination of NASA Research with Airlines

Representatives from the operations, maintenance and engineering disciplines within the ATA member airlines and at ATA are directly involved in NASA aeronautics research programs through frequent participation in the NASA Aeronautics Advisory Committee and its several subcommittees, review and advice provided by two airline technical committees and membership on the Aeronautical Policy Review Committee of the OSTP. Through these coordination mechanisms, the airlines are able to make direct inputs into the NASA programs at the Research Center level and Headquarters.

The airlines have found that NASA researchers are eager to work with people who are involved with a broad range of day-to-day problems. The NASA researchers apply their unique facilities and expertise to near-term problem solving and gain insight that helps them define their longer term basic research programs.

Aviation Safety

ATA carrier comments on aviation safety concerns are offered in the context of the 1987 ATA Safety Agenda, which defines the airlines priority safety program. A copy of the Agenda is attached. ATA has met with NASA to discuss NASA's role in the execution of the Safety Agenda. NASA research is directly involved in several programs in the Agenda dealing with Safety of Flight:

- Reducing the risk of mid-air collisions
- Elimination of encounters with hazardous wind-shear
- Human factors

NASA researchers at the Ames Research Center have been working with the airlines, FAA and equipment suppliers in real-time and full mission simulation of the human interface with on-board TCAS II systems (Traffic Alert and

Collision Avoidance System) and how they can best be integrated onto the flight decks of airline aircraft which utilize conventional displays. This simulation was completed last year with a report expected in the near future. NASA is planning to extend this work to flight decks of modern aircraft which utilize electronic flight instruments. The airlines and FAA have plans to begin the next level of evaluations, in-flight this year. The overall objective of this program is to enhance safety by providing a backup to the ATC system which will avert potential mid air collisions. In the area of wind-shear avoidance, we are pleased that NASA is assisting the FAA and industry in the development of reliable on board aircraft equipment that will remotely detect and display to flight crews conditions that are generally associated with severe weather near airports -- wind-shear, turbulence and heavy rainfall. Reliable on board equipment will complement the FAA and National Weather Service enhanced LLWAS[1/] and ground-based doppler radar detection systems ultimately planned for 115 or about 20% of the domestic airports our members serve. At the remaining airports, on board equipment and pilot reports may provide the only means we will have for wind-shear avoidance.

The new NASA-FAA wind-shear research plan calls for a significant investment by NASA for research in terms of manpower, facilities and funds for developing on board equipment that will provide a predictive sensing capability to detect and display hazardous wind shear conditions. We urge NASA and the FAA to accelerate the pace of this program and to maintain a continued dialogue with industry, including both the developers of new sensors and displays and the airlines who will eventually utilize the equipment in an

---

[1/] Low Level Wind Shear Avoidance System operational environment. NASA should continue studies and simulations both in-house and with industry to identify optimum displays, guidance and piloting techniques to use new wind shear detection methods.

We also recommend that, where possible, NASA participate in the FAA and National Center for Atmospheric Research (NCAR) field research program at Denver during the next two summers. NASA's role in these field studies at locations where we can expect wind-shear to occur, should include evaluations of candidate remote sensing systems against other observations from ground-based doppler radar systems.

Research in NASA wind tunnels has indicated potential aerodynamic and handling quality penalties associated with heavy rain typical of some hazardous wind shears. Planned NASA full-scale tests this year will produce evidence as to the degree of hazard caused by heavy rainfall. If the hazard is significant, the airlines will be able to use the NASA results in further updating the wind-shear data base used in pilot training programs.

The final aspect of safety-of-flight that involves NASA is the human factors area. In this area the airlines are developing a priority work program that would necessitate industry and government participation on: the optimum use of automation to enhance human performance, new technology controls and displays, human performance relating to causal factors in accidents and incidents, pilot-air traffic controller information transfer, and enhanced training. In developing this work program, the airlines have recently completed reviews of the relevant human factors and ATC research at the NASA Ames and Langley Research Centers. We foresee the need for a long term and focused NASA human factors research program that will capitalize on the many excellent NASA facilities and keen interests of the researchers. We believe the FAA must also play a vital role in this work program. While the

Aviation Safety Reporting System (ASRS) managed by NASA for the FAA will be extremely useful in identifying situations that should be examined, we believe that its funding has not kept pace with the volume of reports. Accordingly, there is a need to expand ASRS, whether funded by FAA, or jointly by NASA and FAA.

Modernization of the National Airspace System

The next broad area where NASA research can contribute is in the modernization of the National Airspace System (NAS). Owing to the new NASA simulation capabilities and as a user of the current NAS, NASA can assist the FAA in both short and long term efforts to improve safety, operating efficiency and reduce air traffic delays in the current NAS. Recently, the ATA members have been experiencing about 2000-2500 hours of delay each day. This is the equivalent of grounding a major airline operating 250 airplanes each and every day. One can easily be concerned about how these delays would mount with a 50% increase in passenger demand the FAA forecasts for the 1990's.

NASA is well known for its capabilities in examining new approaches to operations in the terminal airspace surrounding major airports. It appears to us that the NASA InterCenter Working Group task "Operating in the NAS" could be focused more directly on the problems the users and the FAA have today as well as looking to the future.

The earlier-described NASA-FAA wind-shear sensing program should be expanded to include ground-based detection of hazardous wake vortices generated by transport aircraft. Current runway/airspace capacity standards are determined in the main by separation standards predicted upon wake vortex strength, i.e. longitudinal aircraft separation standards intended to protect aircraft from excessive turbulence and upset. Reliable detection and prediction of wake vortex conditions offers the potential of a reduction of longitudinal aircraft-to-aircraft spacing, thereby increasing system capacity. NASA should also reinstitute research to design features into aircraft to alleviate the generation of wake vortices.

NASA and FAA simulations of aircraft operations in terminal airspace include participation by air traffic controllers and should be expanded to include the variables of winds, visibility, wake vortices, various aircraft types, runway occupancy time and runway braking action to identify opportunities where capacity can be increased and delays reduced while safety is enhanced. Available NASA research aircraft should also be used to validate significant simulation findings. As a by-product, NASA could also assist the FAA with studies on changes to NAS productivity due to restructured terminal airspace, traffic flow patterns, modified ATC procedures and handling of more fully automated aircraft.

It makes little sense for the airlines to purchase highly automated aircraft if their full capabilities cannot be utilized in the current and future NAS. We are pleased to learn that NASA and the FAA are planning a new cooperative research plan to increase operating efficiency in terminal airspace. We believe that near term NASA participation in modernizing the NAS will be vital for identification of future NASA and NASA-FAA research aimed at the time frame when we can expect a much higher demand for public travel and the advent of a new generation of aircraft of all types.

Future Transport Aircraft

NASA has developed an excellent program over the years that deals with aircraft tires, brakes and landing gear systems research. This program contributes to improved airport capacity as well as aircraft development. A significant portion of airline maintenance-related delays are attributable to problems associated with these undercarriage components. The NASA Langley National Tire Program is well coordinated and supported by industry. The newly refurbished Landing Loads Track at Langley allows evaluations of improved tires and auto-skid systems at representative operating conditions -- especially at high aircraft speeds and weights and non-standard runway surface conditions. The Langley Terminal Systems Research Vehicle, a highly instrumented Boeing 737, has expanded and is expected to continue to expand knowledge of aircraft braking and controllability on wet and snow covered runway surfaces. The resultant data will be used to update FAA publications, improve runway maintenance and provide guidance in programming training simulators.

NASA is now nearing completion of a ten-year research program on advanced turboprop propulsion. The current NASA, Boeing, Douglas and Lockheed flight test evaluations of novel propfans and unducted fans will provide data to validate earlier small scale research. Some of these new concepts will eventually be implemented on new aircraft designs that will likely be placed in service by ATA members in the early 1990's. We urge NASA to continue and expand development of the technical data base that will be used to validate methods that predict airborne and cabin interior noise and the best means of noise treatment, performance of various configurations, i.e. single/counter rotation, tractor/pusher, and installation aerodynamics. We are pleased that NASA will assist the FAA in the development of certification criteria of these new propulsion systems.

The NASA Lewis propulsion research program also includes aircraft icing protection. This program contributes to aviation safety as well as aircraft development. An excellent national icing research program has been implemented under NASA Lewis leadership due to their unique facilities and

NASA Lewis leadership due to their unique facilities and expertise. The icing program should continue expansion to develop low-cost and efficient ice protection concepts that can be implemented on advanced technology aircraft which will embody advanced aerodynamic shapes, materials and propulsion technologies.

NASA aircraft drag reduction research continues to show promise that laminar flow concepts can further reduce fuel consumption. An airline technical committee has consulted with NASA on the recent Jet Star research flights in simulated airline service. The results are very encouraging and we look forward to further research this year, which will involve hybrid systems installed on transport research aircraft.

In the area of advanced structures and materials, we were disappointed in the NASA decision several years ago, forced by budget constraints, to drastically reduce funding in composite materials, fire and crash safety. Our newest technology aircraft embody the products of the earlier NASA-industry composite materials research program. We encourage NASA to expand structures and materials research and to also include a reliability and maintainability focus as well as concentration on weight reductions to improve fuel efficiency.

We have learned from recent operational experience that further attention is needed in composites, especially in the areas of lightning protection, delamination, inspection and repair methods. If NASA plans an expanded structures and materials program with concentration on composites for transport aircraft, then the above operational problems should be included as part of the research. NASA and the FAA should also examine the fireworthiness and crashworthiness of new materials to ensure that the high level of safety provided by current technology aircraft is enhanced and not diminished. The airlines have presented these needs to the National Research Council (NRC) for consideration in developing recommendations for NASA, DOD and FAA research in the forthcoming NRC study for NASA, "Status and Viability of Composite Materials for Aircraft Structures."

In the area of controls and guidance, we note that NASA is working with Boeing and Douglas on side-stick flight controls in the NASA Advanced Concept Simulator. We encourage NASA to continue further research in the area of protecting advanced controls and guidance systems from the effects of electromagnetic interference and lightning discharge. NASA, DOD, and FAA coordination is necessary to take advantage of available DOD experience. We note also that our new automated flight management systems which include "glass cockpit" displays (cathode ray tubes) evolved from a number of programs, including NASA research. These advanced displays are several times more reliable than the electro-mechanical systems they replaced. This outcome highlights the need for including "affordability" in research programs.

Finally, in the area of advanced technology high speed transport aircraft, ATA has been participating with the OSTP Aeronautical Policy Review Committee in developing the 1985 National Aeronautical R&D Goals and the February, 1987 OSTP sequel report "Agenda for Achievement." The airlines will be reviewing this new report in more detail and its eight action items. While all of the items are important to the nation and our industry, we are especially interested in the action items dealing with the transformation of R&D results into affordable U.S. products, supersonic/hypersonic transports and enhancing the safety and capacity of the National Airspace System. As discussed earlier, NASA can contribute greatly to these objectives.

The OSTP action item dealing with a long-range supersonic transport is an area where the airlines are now directly involved. NASA, Boeing and Douglas are well underway in the High Speed Civil Transport studies that directly bear on this OSTP objective. Six ATA member airlines have been consulting with Boeing, Douglas and NASA on these studies and are providing information on airline operations, technical and economic requirements. The products of these cooperative studies will be more fully developed in late FY 1988 and will indicate where NASA research is required to support the OSTP action item on a potential U.S. industry initiative for a long-range supersonic transport aircraft.

Conclusions

In conclusion, NASA is working well with our industry in defining research needs for both the near and far terms. NASA can contribute greatly to the efficiency and safety of new technology transports and their economic operation in the current and future National Airspace System and provide a knowledge base for use in the certification of new technology aircraft and components. NASA must also be visionary and maintain its independence in carrying out its mandate in aeronautics research. The February, 1987 OSTP "Agenda for Achievement" report provides a coordinated government and industry framework for further definition of NASA aeronautics research in support of the development of civil high speed transport aircraft, affordable products and enhancement of the safety and efficiency of the National Airspace System.

Attachment: ATA Safety Agenda for 1987

Air Transport Association ata OF AMERICA

December 1986

ATA SAFETY AGENDA FOR 1987

The Air Transport Association has adopted a 1987 safety agenda as a priority work program to be accomplished through the various technical committees under the direction of their governing councils.

Introduction

ATA member airlines have historically played a leading role in pursuing improvements in safety for the traveling and shipping public. Since its formation 50 years ago, the ATA and its many technical committees have emphasized the importance of safety above all else. The current list of general industry objectives obliges ATA "to conduct the affairs of the Association in keeping with the primacy of the airline industry's commitment to safety". The safety agenda for 1987 identifies further areas where continuing progress is believed to be achieveable.

Since deregulation of the airlines in 1978, the safety record has continued to improve and, in fact, to surpass the already excellent record of the pre-deregulation years. During one 30-month period since deregulation, ATA airlines operated without a single passenger fatality. Most recently, there has not been a fatal accident on a U.S. scheduled airline in over 15 months.

While the Federal Aviation Administration is responsible for the regulation of safety, it is the individual carrier that bears the ultimate responsibility for safe operation of its aircraft. In this regard, the air carriers benefit from the contributions of the manufacturing industry, first through the availability of reliable, efficient equipment, and secondly through continuous contact and coordination in the service life of the aircraft and its inflight systems. The maintenance techniques and surveillance methods developed by the ATA airlines, in cooperation with the FAA and the manufacturers, have become models for the airlines of the world and the Air Force and Navy.

Safety and security are related matters, and thus the ATA safety agenda addresses opportunities for strengthening the industry's already extensive security procedures.

ATA SAFETY AGENDA FOR 1987

A. Safety of Flight Operations

- Reduce risk of mid-air or ground collision.
  - Complete operational validation of TCAS II and pursue further development by FAA of TCAS III specifications.
  - Pursue effective revisions to Terminal Control Area configuration and related regulations, including expanded requirements for automatic altitude reporting by general aviation aircraft.
  - Seek increased aircrew awareness of the recurring incidents and unique aspects of runway incursion incidents and other ground incidents/accidents.
- Reduce wind shear risk.
  - Seek improved and expanded ground sensing capability (expanded LLWAS and Terminal Doppler Weather Radar) concurrent with the development of the content and means of delivery for simple, up-to-date, runway-specific wind shear information.
  - Support the development of airborne detection equipment which provides pre-entry wind shear warning information to the cockpit.
- Propose an airline/FAA review of pilot training and checking requirements with the objective of identifying the most meaningful, operationally relevant training and checking programs, eliminating current requirements that are duplicative or not contributory to training and checking goals.
- Pursue the priority human factors work program for industry and government agencies focusing on the most beneficial research and application programs. The work program includes study of:

  Human performance in advanced automation and new technology control/display environments as well as human performance as it relates to causal factors in accidents/incidents; human interface issues including pilot/controller information transfer; pilot selection and training enhancements including an assessment of the efficacy of cockpit resource management training and potential for refinements for industrywide implementation.

- Support adequate federal funding for needed human factors research programs.
- Investigate improved methods to achieve a broader, more timely exchange of safety information between the ATA members and within the industry.

B. Safety in the Cabin

- Seek means to better accommodate needs of handicapped passengers without degrading the level of safety afforded all passengers.
- Promote industry-developed standards for safer cabin interior materials.
- Investigate proposals for increased seat safety to determine basis for industry recommendations.
- Reemphasize enforcement of FAA regulations on carry-on baggage.
- Investigate possible causes of hidden fires in aircraft and determine if design changes are appropriate to eliminate or minimize the hazard from such fires.

C. Promoting a Drug-Free Environment

- Press for needed regulatory measures.
- Adopt industrywide or individual carrier programs.

D. Strengthening FAA/Industry Security and Anti-Terrorism Measures

- Encourage FAA development of improved explosives detection techniques and accelerate availability for field test and development.
- Promote development of passenger/baggage match techniques to meet ICAO Security Standard 5.1.4 effective December 19, 1987.
- Pursue efforts to improve the quality of the airline passenger screening process and enhance public confidence in the adequacy of airline security.

- Press for increased government assistance and participation in meeting security requirements at high-threat locations, and continue work toward multilateral strengthening of international security mechanisms.

E. Increase Public Awareness of Airline Safety Programs and Accomplishments

- Pursue participation in, or contribution to the work of the Aviation Safety Commission.

- Maintain a strong public information program to assure broad understanding of the airlines' highest priority commitment to safety, the safety activities of the industry, and the need for modernization to enhance safety and efficiency.

***